A study of the relationship between phonological awareness and phonological processing in four and five year old children

Thesis

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A STUDY OF THE RELATIONSHIP BETWEEN PHONOLOGICAL AWARENESS AND PHONOLOGICAL PROCESSING IN FOUR AND FIVE YEAR OLD CHILDREN

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FOR

MY PARENTS

WHO TAUGHT ME TO LOVE READING

AND FOR

TOM

WHO ENABLED ME TO READ FOR HOURS

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INTRODUCTION

Phonological awareness has been defined as:-

> ' the ability to pay attention to and reflect upon the phonological structure of language. ....(Children realise) that sounds have certain combinations of characteristics which distinguish them from other sounds in the language but also that some of these characteristics are shared with other sounds and as a consequence (sounds) can be grouped and categorised according to these characteristics.'
>
> (Howell and Dean, 1994. p41)

The concept of phonological awareness is an important one in that the child's ability to reflect upon the individual sounds, and the sound system, of the language has been shown to be related to proficiency in oral (for example, Howell, 1989; Magnusson, 1991; Howell and Dean, 1994) and written language (for example, Bowey and Patel, 1988; Goswami and Bryant, 1990; Bryant, MacLean and Bradley, 1990). There is evidence that children who demonstrate reading difficulties also perform poorly on tests of phonological awareness, and programmes have been implemented to try to facilitate metaphonological processing[1] (for example, Torgesen, Wagner and Rashotte, 1994). Other remediation programmes focusing on metaphonological skills have been devised for children with speech processing difficulties (Dean, Howell, Reid and Waters, 1995). Despite this evidence of the importance of metaphonological processing, the nature of 'phonological awareness' has not been clearly defined and its correlates are fiercely debated.

Metaphonology is a level of metalanguage just as the study of phonology is encompassed by the term 'linguistics'. Language structure can be profiled at many levels; for example,

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[1] The terms 'phonological awareness' and 'metaphonology' are used synonymously within this thesis to refer to the ability to reflect on the sound system of the language. Similarly, the terms 'linguistic awareness' and 'metalanguage' are both used to refer to the ability to reflect on language in general.

In line with current terminology the phrases metalinguistic awareness and metaphonological awareness will only be used if they have been employed by the original author. Otherwise the prefix meta- has only been used in the context of. for example, skills, abilities or processing to avoid the tautology inherent in phrases such as 'metaphonological awareness'.

phonology, morphology, syntax, semantics, pragmatics. Similarly, linguistic awareness can be directed at any of these specific aspects of language structure. The current level of knowledge in the field of metaphonology requires that this thesis is informed by literature from the more general area of metalanguage, or linguistic awareness, as a starting point from which to address the specific aim of this thesis; the exploration of the nature and correlates of metaphonological processing

There is evidence that phonological awareness develops throughout childhood but the factors responsible for this development remain a matter of discussion. Some researchers (for example, Donaldson, 1978; Hakes, 1980; Van Kleek, 1982; Tunmer and Herriman, 1984) have proposed that emerging metaphonological skills are linked to cognitive development; suggesting that linguistic awareness (in general) 'flowers' in middle childhood and is related to the development of concrete operational thought. The argument is that the development of linguistic awareness requires the child to shift from a focus on one aspect of a stimulus to another. In the case of phonological awareness, this is a shift from a focus on word meaning to a focus on phonological structure. This skill, termed 'decentering' within a Piagetian framework, is argued to result from cognitive development between the ages of five and seven years.

This theoretical position would lead to the prediction that there would be no difference in the performance of phonologically disordered and normally developing children, with the same intellectual level, on metaphonological tasks. However, recent studies by, for example, Howell (1989) and Magnusson (1991) have found that children who have problems with the acquisition of the speech sound system perform less well than normal children on metaphonological tasks. Such findings suggest that the development of phonological awareness is not purely related to cognitive change, but is also associated with phonological processing difficulties.

There is additional evidence which makes it difficult to accept cognitive development as the predominant influence on phonological awareness. Many reviews have reported instances of children, below the age of five, demonstrating the ability to reflect upon the sound system (for example, Weir, 1962; Slobin, 1978; Kuczaj, 1983; Howell, 1989; Chaney, 1992); findings that again challenge the view that reaching the stage of 'concrete operational thought' is an essential pre-requisite for the development of phonological awareness. Conversely, there is evidence (Morais, Clutyens and Alegria, 1984) that children who can cope with an analogous cognitive task (i.e. a musical segmentation task) may still demonstrate a selective inability to perform phonemic segmentation tasks.

A further debate centres around the relationship between literacy and phonological awareness. Different researchers have argued that literacy skills precede the development of phonological awareness (Morais, 1991); that literacy skills are a co-requisite (Fowler, 1991; Lundberg, 1991) for the development of phonological awareness; or that phonological awareness is a necessary precursor of written language processing (Bryant and Bradley, 1983, 1991; Lundberg, Frost and Petersen, 1988).

Evidence has been gathered from three types of study. One group of researchers (see for example, Bowey and Francis, 1991; Goswami and Mead, 1992) have attempted to relate emerging aspects of linguistic awareness to the development of literacy skills These studies have generally concluded that there is a link between early phonological awareness and success in reading and spelling over the next three years, even when factors such as intellectual level have been taken into account (see, for example, Bryant, Bradley, MacLean and Crossland, 1989). A further set of studies has examined the metaphonological skills of illiterate subjects from countries where reading tuition has not been universal (see, Morais, Alegria and Bertelson, 1979; Bertelson, de Gelder, Tfouni and Morais, 1989; and, for a review, Morais, 1991). Such studies have demonstrated that whilst such subjects may have been able to generate some phonological forms (e.g. rhymes) spontaneously, reflection on the nature of phonological units, particularly phonemes, proved difficult for illiterate individuals (Bertelson, de Gelder, Tfouni and Morais, 1989; Morais, 1991). However, a third group of studies, which have explored the relationship between the metalinguistic, linguistic and literacy skills of young school age children, have yielded differing evidence as to the extent to which early reading ability is influenced by each variable individually (for example, Bowey and Patel, 1988; Bryant, MacLean and Bradley, 1990).

The basis of the controversies about the nature and correlates of phonological awareness could lie, at least in part, in methodological issues. Some studies have failed to take sufficient account of the fact that, as currently understood, linguistic awareness is multi-componential (Lundberg, 1991); perhaps most fruitfully being seen not as a single entity but as a group of related skills. If this is the case, researchers will require to define clearly, and assess specifically, the aspect of linguistic awareness which is the focus of their study. Further, there has been a tendency for researchers investigating the link between linguistic and metalinguistic abilities not to measure, and compare, equivalent skills in both domains. For example, to explore the relationship between linguistic and metalinguistic skills by assessing phonological awareness and vocabulary skills as opposed to profiling and comparing phonological awareness and phonological processing skills.

Whilst previous studies have failed to identify clearly the relationship between metalinguistic and other skills, they have served to highlight the evidence that the relationships between cognitive ability and linguistic awareness, or between linguistic and metalinguistic processing are not simple. The influences on the development of linguistic awareness are complex and require further investigation.

This thesis aims to illuminate the relationship between linguistic and metalinguistic processing by focusing on one specific aspect common to both; phonological processing. That is, it aims to evaluate the relationship between phonological processing and phonological awareness when covariants such as age, nonverbal intellectual functioning, general language processing skills and memory are controlled.

Introduction

The foci of this study are an exploration of the nature of phonological awareness in four year old children; of the variables (specifically phonological processing skills) which have influenced metaphonological processing and of the development in phonological awareness which has taken place by the child's fifth birthday. One outcome will be a better theoretical understanding of the nature of the phenomenon 'phonological awareness'. Further, the study will allow a systematic evaluation of the way in which metaphonological skills are measured and facilitated. With carefully designed assessment procedures it may be possible to identify children with poor metaphonological skills, and therefore at potential risk of reading difficulties, before school begins.

The findings will have implication for the potential selection criteria, design and delivery of programmes to facilitate reading skills. Currently such programmes are implemented for children with literacy difficulties (for example, Bryant and Bradley, 1983; Torgesen, Wagner and Rashotte, 1994), and children with pronunciation difficulties (Howell and Dean, 1994; Dean, Howell, Reid and Waters, 1995). There may be an additional role for intervention programmes to develop phonological awareness in an attempt to maximise literacy skills in advance of any knowledge of literacy levels.

The importance of the current study is that it will allow a better understanding of the way in which facilitation programmes, designed to influence phonological awareness, are structured and implemented. This will have implications for the management of both children with reading difficulties, and of those with speech processing problems, as well as for the education of normally developing children.

This thesis is organised such that Chapters 1, 2 and 3 reflect the current literature in this field. Early papers (for example, Clark, 1978; Read, 1978; Slobin, 1978; Weir, 1962) reported observational studies of the development of phonological awareness. Since then the knowledge base has developed in two distinct ways. First, a body of papers have sought to explore the development of specific aspects of phonological awareness in more detail;

notably awareness of syllables, rime, onset and phonemes. Chapter 1 will review current knowledge about the developmental path of different levels of metaphonological awareness.

Second, researchers have sought to relate early metaphonological skills to later cognitive and linguistic development. These studies have focused on the interrelationship between different levels of awareness and, for example, intellectual functioning, memory skills, language acquisition and impairment, bilingualism, and literacy. This second group of papers will be the focus of Chapter 2. Chapter 3 narrows the focus of the thesis and presents evidence for the inter-relationship between phonological processing and phonological awareness.

Chapter 4 details the process of test construction that has been undertaken and documents the pilot study. Chapters 5 and 6 report the methodology and results of the two investigations carried out within this study. Analysis and discussion of the results of both investigations is presented in Chapter 7 which concludes with a consideration of possible topics for further investigation.

CHAPTER 1
The development of phonological awareness

1.1. INTRODUCTION

1.1.1. Background

One striking feature of the literature in this field has been the debate about the age of acquisition of different metaphonological skills. Some authors (for example, Donaldson, 1978; Hakes, 1980; Van Kleek, 1982; Tunmer and Herriman, 1984) have proposed the view that phonological awareness is related to changes in cognition which only occur around the ages of five to seven years. This is when children both reach the stage characterised by Piaget as concrete operational thought and, in most cultures, begin formal literacy training. Other papers point to instances of children much younger than this demonstrating implicit phonological awareness, through behaviours such as spontaneous speech repair (Weir, 1962; Kuczaj, 1983), spontaneous production of rhyming words (Dowker, 1989), or explicit comment on language structure (Chaney, 1992).

There are several potential explanations for this discrepancy. The papers which report early instances of phonological awareness are reporting observations of the behaviour of individual children (for example, Weir, 1962; Clark, 1978; Slobin, 1978) whereas other studies have looked at the age at which the majority of children reached criterion on particular experimental tasks (for example, Bradley and Bryant, 1983; Chaney, 1992). Thus, the discrepancy might reflect the range and mean of the ability tested, with individual children being reported in the literature precisely because their skills were in advance of what might be expected.

Second, it is arguable that there is a difference between implicit (such as speech repair) and explicit (such as the ability to consciously reflect on the sound form of a word) awareness. Some authors (such as Gombert, 1992) would argue that behaviour such as spontaneous repair of speech sound errors is not performed consciously by the subject, whereas other behaviours, such as the ability to succeed on a phoneme segmentation task, require conscious reflection. Chapter 2 expands on this discussion, describing the position taken by authors such as Tul'viste (1986), Karmiloff-Smith (1986), Galambos and Goldin-Meadow (1990) and Tyler (1991) who have argued, broadly, that conscious, explicit awareness develops later than unconscious, implicit awareness; a distinction that might account for a further portion of the discrepancy.

Finally, there is some evidence that the ability of children to participate in experimental studies of metaphonological skills depends in part upon the nature of the task. Chaney (1992) describes how several investigators have designed tasks, or modified existing experiments, to make them accessible to younger children. The amendments have included giving instructions that capture the interest of younger children, reducing the length or complexity of the linguistic content of the task,. reducing the cognitive complexity of the testing situation by removing non essential components, and simplifying the response required from the child. Chapter 4 presents a discussion of these factors in relation to the test of phonological awareness designed for this study.

It is important to review the literature concerning the metaphonological abilities of preschool children for two reasons central to this thesis; first, to determine whether there is evidence of phonological awareness in preliterate children younger than five years old and second, to explore the issues to consider when constructing a comprehensive assessment of the metaphonological skills of such children.

1.1.2. Observational studies of emerging phonological awareness

One of the earliest papers to discuss the development of metaphonological skills was Weir's (1962) study of Anthony (aged 2;6 years). Weir provides examples of a child, almost asleep, apparently practising and improving his pronunciation. Similarly, Slobin (1978) reports the development of phonological awareness in his daughter between the ages of 2;9 and 5;7, making one of the first contributions to the debate about the relationship between phonological awareness and bilingualism (see section 2.3 for a fuller discussion of this topic). Slobin (1978) presents a summary of the aspects of awareness (in chronological order) which developed during Heida's pre-school years;

- self-corrections
- comments on the speech of others
- explicit questions about speech and language
- comments on own speech and language
- response to direct questions about speech and language

Slobin (1978) noted that attention to sounds seemed to appear earlier than attention to meaning or grammar. From the age of 3;1 Heida was engaging in rhyming, and sound, play, for example:

> ' " Eggs are beggs. Enough-duff. More-bore" Other attention to word details: "It's just the same-*tuna tune*." She made up the name *hokadin* and broke it into syllables: *hok-a-din*.'
>
> (Slobin, 1978. p49)

Clark (1978) provides a slightly different framework for the stages of development of metalinguistic skills:-

1. Monitoring one's own utterances
2. Checking the result of an utterance
3. Testing for reality
4. Deliberately trying to learn
5. Predicting the consequences of using inflections, words, phrases or sentences
6. Reflecting on the product of an utterance

which reflects Clark's (1978) interest in the psycholinguistic aspects of metaphonological development.

Clark (1978) cites examples of spontaneous comment and repair from children as young as 1;7 prompting the question as to whether many of these studies actually report exceptional rather than normal children. Indeed, many children in the early studies were children of linguists who might be argued to have been likely to have engaged in more play focusing on sound structure than the average parent.

However, what is evident from these reported observations is the pleasure children appear to gain from playing with speech sounds (Van Kleek and Schuele, 1987). In his monograph on crib speech Kuczaj (1983) suggests that it is during this naturally occurring activity, which appears to be enjoyable, that children reflect upon newly acquired knowledge about pronunciation patterns.

1.1.3. Experimental studies of emerging phonological awareness

Having set the scene for a discussion of the developmental stages within phonological awareness and considered observed phenomena, it is now time to consider the evidence from experimental studies. There is now general agreement, as evidenced by reviews such as those of Goswami and Bryant, (1990) and Gombert (1992) that experimental studies demonstrate that there is a developmental progression with the child first becoming aware of syllable structure, then of the intrasyllabic units of rime and onset, and finally of individual phonemes.

Specific studies have highlighted parts of this developmental progression. For example, Bowey and Francis (1991) studied three groups of twenty children; a kindergarten group with a mean age of 5;5 years (SD. 2.48), a young first grade group[1] with a mean age of 5;8 years (SD. 1.33) and an older first grade group with a mean age of 6;5 years (SD. 1.62). The kindergarten and the young first grade groups were similar in verbal maturity but the first grade group had begun reading instruction. The younger and older first grade groups were equivalent in reading experience but the younger children were less verbally mature than the older children.

[1]In the American educational system children are admitted to First Grade on entry to school.

Bowey and Francis (1991) found that the first grade groups performed at the same level on tasks of onset, rime and phoneme oddity and better than the kindergarten group. For all groups the onset and rime oddity tasks were of equal difficulty but the phoneme oddity tasks were more difficult. Some of the kindergarten children could perform reliably on the onset and rime tasks but none could perform above chance on the phoneme oddity task.

However, there have been contradictory findings. For example, Walley, Smith and Jusczyk (1986) assessed 12 pre-school children (mean age 5;11 years, range 5;7 to 6;1 years) and 12 second grade children (mean age 7;10, range 7;6 to 8;3) on tasks of syllable and phoneme correspondence and found that a significant factor in determining the perceived similarity of sounds appeared to be the position of the sound units. The linguistic 'level' of a unit (syllable or phoneme) made less difference to the ability to detect similarity between units than the context in which the unit occurred; attention to the beginning of an utterance had developmental priority.

In conclusion, most studies in this area provide evidence to support the notion that there is a developmental continuum with syllable awareness arising first and phoneme awareness being the latest to emerge. This review will be structured to reflect this progression and to take into account other influencing factors such as context. However, it is useful to begin this discussion with an outline of the type of tasks which have been used to tap metaphonological skills.

1.2. THE MEASUREMENT OF PHONOLOGICAL AWARENESS

1.2.1. Background to the measurement of phonological awareness

Many different forms of task have been devised to measure phonological awareness in preschool children. Different task formats do not always tap different sets of underlying competencies; rather there is overlap in the abilities required to perform each test as the discussion within the following chapters explores. However, it is useful to summarise the different test formats that are referred to in the literature in order to facilitate understanding of individual studies. For this purpose the tasks will be summarised under the descriptions most often applied to them in the literature. The terms 'items' and 'constituent parts' will be used to reflect the fact that the same task may be designed to target different levels of analysis. Thus 'item' may refer to words, syllables or phonemes depending on the focus of the test.

1.2.1.1. Judgement tasks

The most common version of these tasks is the Acceptability Judgement task employed by, for example, Howell (1989) in which the child is required to judge whether an item (usually a word) has been correctly produced.

1.2.1.2. Production tasks

These tests involve spontaneous, or elicited, production of an item, for example rhymes (Dowker, 1989) or phonemes (Goswami and Mead, 1992).

1.2.1.3. Synthesis tasks

The most commonly used form of synthesis tasks are blending tasks in which the constituent parts have to be 'blended' together to form a whole (generally a word) which the child has to articulate (for example Yopp, 1988), or indicate understanding by pointing (for example, Chaney, 1992).

1.2.1.4. Analysis tasks

Oddity tasks require the child to indicate which item does not have the target characteristic. For example, in the study by Kirtley, Bryant, MacLean and Bradley (1989) the child is asked to select the 'odd one out', on the basis of the initial phoneme, from a set such as 'man, mint, peck and mug'.

Segmentation tasks involve the child in breaking down an item (word or syllable) into its constituent parts (syllables or phonemes); for example, in the study by Liberman, Shankweiler, Fischer and Carter (1974) which required children to tap out the number of syllables in a word. Other studies have asked children to indicate, for example, the initial sound in a word (e.g. Stuart, 1990; Warrick and Rubin, 1992; Chaney, 1992).

Deletion tasks have required the child to delete part of an item. Bruce (1964) asked what word would be left if the first sound was removed (for example 'at' being derived from 'pat'). Fox and Routh (1975) asked the child to say a 'little bit of a word'.

Having considered an overview of the task formats used to assess phonological awareness it is possible to review the current state of knowledge about the development of metaphonology.

1.3. THE DEVELOPMENTAL SEQUENCE

1.3.1. Awareness of syllables

1.3.1.1. The developmental progression

Treiman and Breaux (1982) present interesting evidence that young children attend to overall similarity, rather than to single phonemes. In a study of 22 subjects (mean age 4;4 years, range 3;6 to 5;5 years) Treiman and Breaux found that preliterate children classified syllables such as /bɪ/ and /vɪ/ as similar more often than they do /bɪ/ and /bo/ despite the fact that the latter pair share a common phoneme. Treiman and Breaux (1982) found that training the children on this task made no difference to their performance.

The authors argue that these young children were sensitive to the overall phonetic similarity of whole syllables. A comparison group of college students, given a similar task, demonstrated sensitivity to the common phonemes. However, the adults were able to detect overall similarity on tasks where the items did not have a common phoneme. Treiman and Breaux (1982) argue that, whereas similarity relations appeared to be secondary to common phoneme relations for adults, the results suggest that, for preliterate children, similarity relations are primary and the ability to use common phoneme relations is largely absent. Children may not use common phoneme relations because they 'fail to notice' (p584) common phonemes.

However, Treiman and Breaux (1982) argue that to claim that pre-school children only recognise overall similarity and have no ability to detect common phonemes would be an oversimplification. Their research suggests that children have some ability to appreciate common phoneme relations. For example, in a second experiment 17 children with an average age of 4;8 years (range 3;9 - 5;5 years) and a group of adults (college students) were taught (non word) 'names' (stimuli from the triads used in the first experiment), diverted for one minute, and then asked to select each animal from their 'name'. Unsurprisingly, the adults learnt the animal 'names' more quickly than the children. The errors made by the children (predominantly similarity confusions) led Treiman and Breaux (1982) to conclude that the preschool children's focus on similarity relations also extended to influence initial coding of information in memory.

However, in the delayed condition, the children's errors did not differ from the adults. Treiman and Breaux (1982) suggest that further study will be needed to investigate this unexpected finding. They argue that explanation does not lie in the properties of metalinguistic tasks because the children used overall similarity relations in tasks that do not require explicit language judgements, as well as in ones that do. Treiman and Breaux (1982) conclude that the explanation for children's use of overall similarity relations may ultimately depend on the memory processes they adopt/use. Situations in which children use similarity relations may tap initial encodings of syllables, whilst situations in which children use phonemic representations may tap long term memory structures.

Treiman and Breaux (1982) argue that their proposal is consistent with recent conceptions of memory development in which development is seen to affect the control processes of memory, the processes of encoding and retrieval, rather than the basic memory structures themselves (see section 6.3.5. for a full discussion of the influence of phonological memory on phonological awareness). The authors also suggest that exposure to literacy may have a role in these developmental changes. However, neither speech, language or memory processing skills were measured in the pre-school subjects making interpretation of these hypotheses problematic.

1.3.1.2. The acoustic properties of syllables

Evidence that children find the whole sound easier to discriminate and/or manipulate than the phoneme has led researchers to design experiments which focus on the level of the syllable. There is support from acoustic analysis for such a focus, as the syllable contains the vocalic nucleus which provides a clear audible cue by its distinctive peak of energy (Stackhouse, 1990) whilst units smaller than the syllable are not so clearly marked. Phonemes are 'contaminated' by coarticulations whereby their physical characteristics are modified by their phonetic contexts. (For further discussion see section 3.4.2.)

1.3.1.3. Experimental studies of syllable awareness

Liberman, Shankweiler, Fischer and Carter (1974) devised a task in which the child was required to tap each time a syllable was heard. Children as young as five years were able to tap out the number of syllables. Comparing the results with a similar phoneme detection task, Liberman et al (1974) concluded that it was easier for the children to indicate the number of syllables than phonemes. This task can be criticised on the grounds that, due to the rhythmic nature of tapping and the fact that the rhythm of a word is captured in its syllables, the syllable tapping task imposed less of a cognitive load than the phoneme tapping task. However, similar results were also achieved by a different research group (Treiman and Baron, 1981) using a different task format; asking the children to lay out a token for each syllable/phoneme heard. Once again the five year old children had some success with the syllable task whilst being unable to segment words into phonemes.

A study by Whitworth and Zubrick (1983) of 120 children provided an example of what was intended to be a syllable detection task, but which (the authors speculate) due to its nature, proved very difficult for the children tested. The researchers asked children to find a 'little word' within a test item; for example to segment 'can' from 'candle' or 'shoe' from 'tissue'. Only 65% of the 6;6-6;11 year old group were able to segment the initial syllable and only 25% the final syllable. Whitworth and Zubrick (1993) suggest that the difficulty lay not only in segmentation skills, but also in the ability to detach the test word from its semantic referent; further illustrating the importance of considering the cognitive load of individual tasks.

1.3.1.4. The shift from a syllabic to a segmental focus

Further support for the argument that pre-school children can segment syllables was provided by a study which used a different type of task. Having been interested by Tunmer, Bowey and Grieve's (1983) assertion that children may resort to a syllable segmentation strategy when encountering difficulties on a phoneme segmentation task, Chaney (1989) studied children's understanding of word boundaries. The subjects were 34 monolingual (English) children aged between 4;7 and 6;1 (mean 5;2) years. The task involved asking children to say a passage they knew by heart such as the American Pledge. The experimenter asked the child to say the passage slowly "....so that I can write down the words." Analysis of the children's responses revealed that there was a continuum of increasingly mature segmental skills from the use of a phrasal, to a syllabic and finally a word segmentation strategy.

This hypothesis, that the phoneme is not the initial unit of perception is compatible with Bird and Bishop's (1992) conclusion (see section 3.2.8. for a fuller discussion of this study) that the problem for the phonologically impaired child who attempts a metaphonological task lies not only in discovering the criteria for phoneme categorisation, but also in recognising that words *can* be analysed at the level of phonemic segments.

Waterson (1987) argued that early speech perception is based on the salient auditory cues in phonetic patterns of words and that word recognition is achieved by a process of pattern matching. During the course of development the child makes increasingly fine distinctions, gradually incorporating the less salient features into the lexical-phonetic representations until the representations match those of the adult phonological system. In this view, first words are shown to be constructed not on a segmental basis (analytical processing) but on patterns resulting from holistic processing of whole words or word groups. One consequence will be that if the child treats each new word as an analysed whole and fails to perceive that it is composed of the same basic elements as other words, each new word will have to be learned individually and there will be little generalisation to novel forms. (See section 3.2.4. for a fuller discussion of the implications of Waterson's theory.)

If, as Boucher (1994) claims, additional evidence from studies of speech errors, illiterate subjects and pre-readers all emphasise the role of the syllable as the basic unit of speech production and perception, this level of analysis must be considered in interpreting published work. Indeed, Bertelson and de Gelder (1991) suggest that the assumption that some rhyming tasks require recognition of the string common to the rime may be unfounded. They argue that it is at least equally possible that a judgement could be made on the basis of a global impression of phonetic similarity. The next section considers the evidence for the importance of the intrasyllabic units of onset and rime.

1.3.2. Awareness of rime and onset

1.3.2.1. Introduction

Words can be divided into units that are smaller than the syllable but larger than the phoneme. These phonological units are termed the 'onset' and the 'rime'; the opening and end parts of a syllable respectively. In turn, the rime can be divided into the peak (or vowel nucleus) and the coda (the phonemes that come after it). For example, in the word cat, /k/ would form the onset, /a/ the nucleus, /at/ the rime and /t/ the coda.[2]

[2] Within this discussion it was the intention to reserve the term 'rime' for the metaphonological ability to detect the peak/coda unit, and the term 'rhyme' for the linguistic entity. Whilst this intention holds, it has proved impossible to maintain this distinction on all occasions due, primarily, to the variation in the terminology adopted by individual researchers. The exceptions to this convention occur when the term 'rhyme' is used by the original author to refer to the metaphonological ability to detect the peak/coda unit.

Do these intrasyllabic units have any form of reality? Treiman (1988), looked at the evidence that the peak is more closely linked to the coda than to the onset (the phonemes that come before the peak) She carried out two experiments. The first concerned the distributional constraints which are hypothesised to be closely related to the syllable structure; for example, the constraint that long vowels and diphthongs are excluded, in English, from occurring before a three consonant cluster. If this hypothesis is correct, the nonsense word /aimpt/ would be judged less acceptable than /ampt/ because the former violates this distributional constraint and the latter does not.

Treiman (1988) found that subjects did rate nonsense syllables that violated certain proposed constraints between the onset and the following phonemes as less acceptable than syllables that conformed; evidence that speakers are sensitive to these constraints. During a second experiment subjects were asked to combine parts of two nonsense syllables to form a third. The findings indicated that subjects preferred to group the peak with the coda (for example, choosing to combine 'klum' and 'swaus' to form 'klaus', rather than 'klus') which Treiman (1988) argued to be supporting evidence for the hypothesis that syllables have an onset/rime structure which has a measure of reality for adult speakers.

Treiman's (1988) first experiment identified constraints between the onset and the peak. However, from a psychological point of view there did not seem to be a close relationship between subjects' sensitivity to distributional constraints between phonemes within syllables, and their judgements of syllable structure (as evidenced by the subjects' groupings of phonemes within a syllable). Treiman (1988) discusses the possible reasons for this finding suggesting:-

- that peak/coda constraints are more severe/numerous than onset/peak constraints and therefore, even if subjects are sensitive to distributional links between peaks and onsets, they will usually group peaks and codas together.

- there is the possibility that the apparent sensitivity to distributional constraints observed in the first experiment does not actually reflect knowledge of these constraints; i.e. subjects may judge acceptability of non words by comparing them with known words, rather than by using rules to allow certain syllables and exclude others.
- as with syntax (Davis (1983) in Treiman, 1988) co-occurring restrictions may not be a valid test of constituency.

Which ever of these possibilities (or combination of possibilities) is correct, Treiman (1988) suggests that caution must be displayed when drawing conclusions about syllable structure from distributional evidence. However, confirmatory evidence comes from experiments in which subjects show a strong preference for peak/coda groupings rather than onset/peak groupings, and from other evidence involving word games (i.e. pig latin), speech errors and memory errors. Treiman and Danis (1988) used three experiments to study subjects short-term memory for spoken syllables. Analyses of subjects errors showed that, within a syllable, phonemes were not equally free to break apart and combine. Certain groups of phonemes tended to behave as units. Treiman concludes that, taken together, the evidence shows that the peak and the coda form a unit in the way that the onset and peak do not.

1.3.2.2. The relevance of 'rime' and 'onset' to metaphonological skills

Words 'rhyme' when they share the same rime, thus this intrasyllabic unit has great significance in the development of phonological awareness reported in the literature. Children have been reported (Read, 1978; Bryant and Bradley, 1985; Goswami and Bryant, 1990) to perform successfully at an earlier age on tasks involving rime and alliteration than on tasks which require them to manipulate, separate or rearrange the individual phonemes. Dowker (1989) suggests one possible explanation is that

> 'children begin first with an awareness of rhyme and alliteration and, through that awareness, develop a more general phonological segmentation ability.' (p199)

In her own study Dowker (1989) investigated young (between 2 and 6 years old) children's ability to produce poems, which were then analysed with respect to the presence or absence of rhyme, alliteration and/or other phonological devices. She found that 78 of the 133 children produced 606 poems between them. There was no obvious age trend for rhyme but the use of alliteration declined with age. There were no significant age differences in the relative frequency with which phonemes were involved in the rhymes although /d/ and /b/ were the most frequently repeated in alliteration. It is interesting to note that, within Dowker's study, children with limited English (due to it being a second language) were surprisingly willing to engage in the tasks and some were prolific in their production of poems. The influence of bilingualism on phonological awareness is considered further in section 2.3.

Van Kleek and Bryant (cited by Van Kleek, 1994) provide evidence of children as young as 1;6 engaging in rhyming play, and some evidence of the conscious awareness of the rhyming process from 2;0. Dowker (1989) suggests that these findings make it unlikely that the primary purpose of this rhyming and 'sound' play is to practice particular phonemes, and proposes that one possible function is to facilitate the development of phonological awareness (see also, Weir, 1962; Kuczaj, 1983; Bryant, Bradley, MacLean and Crossland, 1990; Van Kleek, 1994; who drew similar conclusions).

1.3.2.3. The developmental progression

Further evidence for this proposal was provided by a study (Bryant, Bradley, MacLean and Crossland, 1989) of 64 children from a variety of backgrounds with an average age of 3;4 (range 2;10-3;9). Bryant et al (1989) tested knowledge of nursery rhymes, and phonological awareness (as measured by rhyme and phoneme oddity tasks). Bryant, Bradley, MacLean and Crossland (1989) found that, after controlling for age, intellectual development and mother's educational level, the children's knowledge of nursery rhymes predicted both phonological awareness over the next two years, and success in reading and spelling two to three years later. Further, the connection between knowledge of nursery rhymes and reading and spelling disappeared when differences in phonological awareness were controlled for. Bryant, Bradley, MacLean and Crossland (1989) suggest that this interrelationship reflects the child's growing sensitivity to the component sounds in words.

Kirtley, Bryant, MacLean and Bradley (1989) also challenge the notions that the development of metaphonological awareness is dependent on literacy skills, and that awareness of rhyme is not connected to awareness of phonemes, or to later literacy skills. They argued that if tests of phoneme awareness were adapted so that the relationships between the individual phoneme and the onset, and between the individual phoneme and the rhyme, were taken into account a different picture would emerge. They studied five (mean age 5;0), six (mean age 6;1) and seven (mean age 7;3) year old children, predicting that if a single phoneme formed the onset children would be able to detect it before learning to read. Similarly, Kirtley et al (1989) hypothesised that children would be able to detect a common vowel (for example in the triplet 'lip, hop, tip') when all three items end with the same consonant but the odd word has a different rime. Kirtley, Bryant, MacLean and Bradley (1989) (see section 6.2.1. for additional discussion of this study) found support both for Treiman's notion of intrasyllabic units, and for their own hypotheses, and concluded that the clear distinction that is sometimes made between awareness of rime and awareness of phonemes may be misleading:

> 'There is more to the phonological awareness of young children than their evident skills with rhyme: they can isolate single phonemes when these form the onset of the words that they hear. Moreover their widely acknowledged facility with rhyme is readily explained by the onset-rime distinction, because rhyming words are words with common rimes.'
> (Kirtley, Bryant, MacLean and Bradley, 1989. p243)

1.3.2.4. The relationship between awareness of rime and onset and literacy

The study of preschool children's ability to produce and detect rime has also been valuable because work such as that of Bryant, MacLean and Bradley (1990) (see section 2.3.4.5. for a fuller discussion of this study) has demonstrated not only that young children can analyse the constituent sounds in words but also that these skills are a powerful predictor of later reading success for three, four and five year old children. Indeed there is now persuasive evidence that the intrasyllabic units of onset and rime have a crucial role to play in the way children learn to read and spell through drawing analogies with words already familiar to them (Goswami and Mead, 1992).

1.3.2.5. Other intrasyllabic units

Whilst Treiman (1988) has argued that the distributional link between the nucleus (or peak) and the coda is more salient for adult speakers than that between the onset and the nucleus (see Section 1.3.2.1.), Bertelson and de Gelder (1991) propose that the latter may still be a significant unit; if not from the point of view of phonological structure (i.e. as a linguistic unit), from an acoustic-phonetic perspective. They suggest that essential information about the initial consonant is provided by its link with the following vowel. Bertelson and de Gelder argue that Bryant and Bradley's (1983) work can be reinterpreted in the light of this argument. Bradley and Bryant asked children to judge auditorily presented words (e.g. 'pig, 'pit, 'pill', 'fin') for the odd one out. Bertelson and de Gelder argue that the choice need not necessarily be made on the basis of recognition and categorisation of initial phonemes (as Bradley and Bryant argue) but on the basis of judgement of the initial consonant vowel (CV) sequence. Bertelson and de Gelder (1991) adapt Bradley and Bryant's (1983) design by altering the items to i.e. 'pit', 'peg', 'pull', 'fan' arguing that this removes the initial onset/nucleus consistency by pairing the initial phoneme with a different vowel within each item..

Klima (1991), however, points out that success on Bertelson and de Gelder's (1991) task still does not provide clear evidence of the importance of the onset nucleus unit. This is because the judgement could have been made on the basis of the onset/initial phoneme alone. He argues that Bertelson and de Gelder's (1991) hypothesis would need to be tested with a set of items in which the initial phoneme and the onset are not always synonymous units i.e. a set of words whose onsets included clusters; for example, 'clean', 'crack', 'coat'.

1.3.3. Awareness of phonemes

1.3.3.1. Introduction

There is evidence for a third way to divide a word into constituent parts; division into phonemes (or speech sounds).

> 'A phoneme is the smallest unit of sound that can change the meaning of a word. "Cat" and "mat " sound different and have different meanings because they differ in terms of one phoneme.'
> (Goswami and Bryant, 1990. p2)

For some authors the term 'phonological awareness' appears to refer primarily to awareness of phonemes (for example, Torgesen, Wagner, Bryant and Pearson, 1992) but this is a rather narrow definition given what is now known about the interrelationship between different levels of metaphonological skills (for a discussion see, for example, Morais (1991a) and also sections 1.3.1. & 1.3.2. which discuss the contribution of syllabic and intrasyllabic awareness).

In a sense it is not surprising that awareness of the phoneme develops gradually, and later than other aspects of phonological awareness, because the phoneme is an abstract concept. Instrumental analysis, such as spectography, indicates that within the acoustic signal the phonemes which comprise a word are not represented separately from one another but are merged together. Phonemes influence, and are influenced by, their context; a phenomena termed 'coarticulation' (Hardcastle, 1982).

1.3.3.2. The developmental progression

The development of phonemic awareness has been studied in a variety of tasks including phoneme deletion (for example, Bruce, 1964; Fox and Routh, 1975; Calfree, 1977), phoneme correspondence (for example, Libermann, Shankweiler, Fischer and Carter, 1974; Treiman and Baron, 1981), phoneme categorisation tasks (for example, Whitworth and Zubrick, 1983; Bradley and Bryant, 1983; Bowey and Patel, 1988), phoneme synthesis (or example, Chaney, 1992), and phoneme segmentation (for example, Whitworth and Zubrick, 1983). As discussed above (1.1.1.), the nature of the task influences the age at which children can be said to have reached criterion on a test of phoneme awareness.

Several authors have attempted to identify a hierarchy of tasks tapping phoneme awareness at different ages. Berthoud-Papandropoulou (1978) investigated the phonological awareness of 163 children aged between four and twelve years. She found that children's judgements of length of a word were initially not related to any concept such as the number of phonemes, but were related to the meaning of the word. She quotes the child who argues that cupboard is a long word ".... because there's a lot of stuff in it"(p58) and similarly another who argues that a short word is "An eye, because it's small." (p58). Tul'viste (1986) quotes a study by Karpova and Kolobova (1978) in which, when asked to distinguish the sounds in a word, all three and four year olds (and a few six year olds) based their answer on the meaning of the word. He gives the example (translated from the original Russian)

> 'What is the first sound you hear in the word *myach* [ball]?" - " At first a sound that has a stripe." "And what other sounds do you hear?" - "Two more: one is red and the other is blue.' (Tul'viste, 1986.p73)

Whitworth and Zubrick (1983) studied the emergence of the concepts 'word' and 'sound' in four to six year old children. They reviewed conflicting evidence from earlier studies; suggesting that the reason for this confusion was the diverse methods used to assess the children's knowledge. For example, Bruce (1964) had concluded that children with a mental age of below 7;0 years could not analyse words into individual speech sounds. The test Bruce used was a word analysis test asking what word would be left if a particular sound was taken away from the test item. Fox and Routh (1975) contradicted Bruce's findings and argued that the four year old children that they studied could segment over half the syllables presented into individual sounds. The task was to "say a little bit of '...........'". This task appeared to allow children to demonstrate segmentation skills at a much earlier age. Fox and Routh (1975) suggested that their results were related to the lower cognitive demands placed on the child.

Whitworth and Zubrick (1983) looked at 120 children and selected a stratified sample from randomly selected day care centres around Perth, Australia. All the children were monolingual, and were judged by their teachers to have normal speech and language development. Fourteen tasks were developed to allow testing of word analysis, phoneme segmentation, and word categorisation. Whitworth and Zubrick (1983) found that their results supported previous findings that young children often use, and respond to, terms such as 'word' and 'sound' correctly within particular contexts. The concept of sound was apparent in the results of the majority of the five year olds and all the six year olds. The skill of segmenting the initial phoneme was emerging in four year old children but did not become consistent in the majority of children until six years of age. These results contradict those of Bruce (1964) but support those of Fox and Routh (1975).

As part of a later study Chaney (1992) profiled the phonemic awareness of forty three children with a mean age of 3;8 years old (range 2;9-4;2 years). The children were monolingual English speakers from a variety of social backgrounds. Within the study 93% of children could perform a phoneme synthesis task, 91% could make judgements about phonemes, 88% performed above chance on a phoneme correction task, 28% could produce words with a specific initial sound and 14% could identify a specific initial sound within words. Chaney (1992) argues that her findings support the thesis that phonemic awareness develops gradually over the pre-school years. Further, Chaney's results provide some support for Wagner, Torgesen, Laughon, Simmons and Rashotte's (1993) findings that preschool children perform better on phoneme synthesis tasks than on tasks, such as segmentation, which require phonemic analysis (see section 3.2.6. for a fuller discussion of this study).

Focusing on slightly older children, Stuart (1990) tested 8 children from an inner city primary school, aged between 4;6 and 4;8 years. Six of these children were monolingual English speakers and two bilingual. Stuart found that, on a phoneme segmentation task, none of the children could identify medial sounds, four of the children were competent at initial phoneme segmentation and three of these could reliably segment final phonemes. The analysis of the results of this study is complicated by the fact that, at the final testing, individual subjects had had between three weeks and one term of schooling. However, it is interesting to note that on a sound letter matching task five of the children (including the four competent segmenters) scored better than chance supporting the link between phonemic awareness and grapheme-phoneme correspondence.

1.3.3.3. The relationship between phoneme awareness and literacy

The marked interest in phoneme awareness has its roots in the growing evidence that there is an interrelationship between phonological awareness and literacy skills. Many studies have investigated this link (for example, Bowey and Patel, 1988; Bradley and Bryant, 1983; Bryant, MacLean and Bradley, 1990; Chaney, 1992; Dreher and Zenge, 1990; Torgesen, Wagner, Bryant and Pearson, 1992. These studies are reviewed in section 2.3.4. Much of this work focuses on awareness of phonemes, as the interaction between awareness of intrasyllabic units and the awareness of phonemes (see section 1.3.2.) has only recently come to be recognised.

However, a review of the literature suggests that the nature of the interrelationship of phonological awareness and literacy is complex. Whilst many studies have highlighted evidence that poor readers tend to have poor metaphonological skills (see 2.3.4.) it is still far from clear whether metaphonological skills directly affect literacy (or vice versa), or whether both deficits are attributable to a third, shared process that is impaired. Papers have cited memory limitations (for example, Felton and Brown, 1990, Gathercole and Baddeley, 1993; Gathercole, Willis and Baddeley, 1991; Naslund and Schneider, 1991; Snowling, Goulandris, Bowlby and Howell, 1986), speech perception (Snowling, Goulandris, Bowlby and Howell, 1986), morphological awareness (Carlisle and Nomanbhoy, 1993) and grapheme phoneme conversion skills (Byrne and Fielding-Barnsley, 1989) as possible contenders for such a `third shared process'. (see sections 2.3.4.4. & 2.3.5. for further elaboration of this discussion.) Currently the debate is theoretical. Having defined 'phonological processes' as the linguistic operations that involve utilisation of information about the phonological (speech sound) structure of the language, Felton and Brown (1990) go on to argue:

> 'Of even greater importance than these theoretical issues are the practical implications of the interrelations among measures of phonological processes. Information concerning the most valid and useful combinations of measures for the accurate prediction of reading abilities will provide guidelines for the identification of children at risk for reading problems prior to reading instruction. In addition, such information should be useful in specifying potential instructional strategies for early intervention.
>
> (Felton and Brown, 1990. p41)

Having considered evidence concerning the development of phonological awareness, it is necessary to turn briefly to a closely related area of linguistic awareness, communicative awareness. The child's growing awareness of the communicative demands of a situation, and of the listener's needs, may 'trigger' the attention to the sound system which comprises phonological awareness.

1.4. AWARENESS OF COMMUNICATIVE SUCCESS

1.4.1. Introduction

The ability to repair communication breakdown can be seen as a metalinguistic skill because it requires the ability to focus and reflect on the language unit that may potentially be repaired; to be sensitive to the cues listeners use to indicate communication failure; and to repeat/modify an message when appropriate. Kahmi (1987) notes that studies have indicated that children as young as 2;10 years can respond to contingent queries in conversations with a peer; and that, as children get older, their responses to such queries include more precise specification of the information needed for clarification.

1.4.2. The developmental progression

Clark (1978) suggests that the ability to make judgements about linguistic structure and function, deciding what utterances mean and whether they are grammatical, appears at about the age of two years. As such, it is one of the earliest metalinguistic skills. Several studies have looked at children's ability to correct syntactically and semantically anomalous utterances (see for example, Hakes, 1980; Kahmi and Koenig, 1985; Galambos and Goldin-Meadow, 1990; and section 2.3.3.7).

Whilst there are many examples of children making spontaneous comments about pronunciation (see section 1.1.2.) there have been few studies of children's ability to make judgements about, and corrections and explanations of phonetic/phonological errors (see sections 2.3.3.3. to 2.3.3.6 for some examples from the study of language disordered children).

Hakes (1980) carried out an experimental investigation of the acceptability judgements of 100 children divided equally into five groups aged between four and eight years old. He asked the subjects to judge acceptable, semantically and syntactically anomalous sentences. Hakes found that acceptability was age related and hypothesised that as children get older their judgements are based on an increasing number of criteria. Initially, the acceptance/rejection is based purely on whether the sentence is meaningful to the child. Around the age of four years the criteria moves towards content. By seven to eight years of age, Hakes suggests that the judgement is based almost entirely on linguistic criteria with meaning and content playing a subsidiary role.

Kahmi and Koenig's (1985) review of the literature supports Hakes's (1980) argument suggesting that young children have difficulty making out of context judgements until about the age of four and that when explanations do emerge their focus is first on the meaning and only later on the form of the utterance.

Adjusting output in response to perceived listener needs is considered, by Kahmi (1987), to be a metalinguistic skill because it requires the ability to empathise with the listener role, and to manipulate form. There is debate as to the extent to which, at the outset, this behaviour is conscious (see Van Kleek, 1982); early adjustments may not be deliberate but as linguistic awareness increases the child develops the ability to both make adjustments and to judge consciously the appropriateness of those adjustments. Kahmi (1987) suggests that this ability has been observed in children as young as three years of age.

1.5. LEVEL OF AWARENESS

1.5.1 Introduction

Having considered the evidence for a developmental progression from awareness of syllables, through awareness of rime and onset to awareness of phonemes; there is a second perspective which must be noted here and which will be explored further in sections 2.2.2. & 2.2.3. That is, the level of awareness demonstrated by the child within each stage (syllabic, intrasyllabic and segmental). Several studies (for example, Clark, 1978; Karmiloff-Smith, 1986) have noted and explored the evidence that children begin by being able to repair, firstly their own utterances and later those of others, and progress to being able to verbalise the basis for these repairs. Evidence that this developmental progression is also apparent within the development of phonological awareness comes from studies such as Rubin, Mallory, Farndale, Howe and Rubin (quoted in Warrick and Rubin, 1992) and Chaney (1992).

1.5.2. The developmental progression

For example, Rubin et al. designed a series of tasks to test out the continuum proposed by Clark (1978). The assessments measured three to six year old children's spontaneous ability to revise, judge, correct, identify, repair, manipulate and explain errors in the phonological form of words. The results suggested that the proposed continuum had some reality with three year olds being able to make some correct judgements and repairs. Similarly, Chaney (1992) found that, of the three year old children that she studied, nearly all were successful in judging and correcting phonemes but had more difficulty in identifying initial sounds. Bialystok and Ryan (1985a) argue, based on their model of emerging linguistic awareness, that such a progression in due to an increase in the analysed knowledge required to perform different tasks (see sections 2.2.4. for a fuller discussion of the cognitive control underlying the development of phonological awareness).

1.6. CAN PHONOLOGICAL AWARENESS BE ENHANCED?

1.6.1. Introduction

There have been several attempts to develop phonological awareness in children These studies have generally been in the context of evaluating the effect of such programmes on later reading and spelling skills (see for example, Bradley and Bryant, 1983; Lundberg, Frost and Petersen, 1988; Lie, 1991; Byrne and Fielding-Barnsley, 1992; Torgesen, Wagner and Rashotte, 1994) although Howell and Dean (1994) report a small scale study designed to facilitate phonological awareness in phonologically disordered children.

The majority of facilitation programmes have been targeted toward preschool (and preliterate) children aged between five and six, have been carried out in countries where the school entry age is around six years of age and have compared the target group with a control group who has had a different (non-phonological) intervention. Comparison of the findings of these studies is complex due to differences in subject populations in terms of variables such as age; bilingualism; literacy skills on entry to the programme; timing and content of training programme; and pre-, and post-, tests and outcome measures. However, a summary of the findings of these studies provides some indication as to whether the development of phonological awareness can be influenced by facilitation programmes.

1.6.2. Facilitation studies

1.6.2.1 Enhancing reading skills through developing phonological awareness

Bradley and Bryant (1983) carried out one of the first such studies investigating 65 children aged six years old when training started. The children were divided into four groups matched for age, verbal intelligence, and sound categorisation scores (a phoneme oddity task). The children were given 40 individual training sessions spread over two years. The content of the intervention varied according to the group. Group I had training in sound awareness; rhyme and alliteration skills. Group II had similar training to Group I but their programme also included grapheme-phoneme correspondence tasks. Groups III and IV were control groups, with Group III engaging in conceptual categorisation and Group IV having no intervention.

The results reported by Bradley and Bryant (1983) were that Group II did better than Group I on final reading and spelling tasks and both did better than Group III. This finding was significant for the difference between Group II, and Groups III and IV. There was no difference between Groups II and I on the final reading test but there was a significant difference on the spelling test. These findings suggest that training in phonological awareness was influential, but was most effective for later literacy skills when it was specifically connected with letter/sound knowledge. This effect was specific to literacy with mathematical tests showing no corresponding change.

In a large scale study of 235 six year old preschool children, Lundberg, Frost and Petersen's (1988) training programme involved listening games (word and nonword items), rhyming games, sentence segmentation (into words), word segmentation (into syllables) and word segmentation (into phonemes). The subjects received daily training for eight months. There was a comparison group of 155 children who received no metaphonological intervention. On final testing Lundberg, Frost and Petersen (1988) concluded that there were small, but significant effects on tasks involving rhyme, and word and syllable manipulation. To some extent these effects were masked due to ceiling effects for some of the subtests. However, there was a substantial change in the phoneme segmentation skills of the experimental group. The intervention also had a marked effect on the reading and spelling skills of the experimental group; an effect which was specific to literacy as there was no change in performance on mathematical tasks. Goswami and Bryant (1990) argue that Lundberg, Frost and Petersen's (1988) findings imply that, as phoneme awareness was the most important effect of the facilitation programme, a direct relationship between phoneme detection and literacy can be assumed.

Lie (1991) investigated the effect of a metaphonological facilitation programme administered to 112 preschool children with a mean age of 7;2 years. Although this study was rather poorly controlled, it is of interest (in the light of Bradley and Bryant's (1983) study) because Lie compared the effect of two different facilitation programmes with the performance of a comparison group who received non phonological intervention. 60 of the experimental children received training in phoneme identification (Group A); the recognition of phonemes in different word positions. The remaining 52 children in the second experimental group (Group B) carried out the same activities as Group A, but also engaged in phoneme blending activities. Group B performed significantly better than the control group at the end of the first year at school. Group A had higher scores than the comparison group but this difference was not significant. Both Group A and Group B were significantly better than the control group on the spelling test administered at the end of the first year; with Group B (who had received the additional blending exercises) being significantly better than Group A. However, this effect had disappeared by the end of the second year at school.

Further, support for Bradley and Bryant's (1983) finding of the combinatory value of phonological awareness and letter knowledge was provided by Byrne and Fielding Barnsley's (1991) evaluation of a facilitation programme. They studied 64 experimental and 62 control subjects who had equivalent vocabulary skills and metaphonological abilities. The mean age of both groups was 4;7 years and they received 25-30 minutes training, once per week, for 11 weeks. The experimental group were taught one phoneme in one position (e.g. in initial position) each session. The control group had training in semantic categorisation.

On post-testing the experimental group performed significantly better than the control group on trained phonemes, as well as on phonemes that had not been the focus of the facilitation programme. Byrne and Fielding-Barnsley (1991) argue that this finding suggests that phoneme identification is a stable construct once it has been achieved and therefore that facilitation programmes do not need to target all phonemes in a language. A forced-choice word recognition task provided evidence that most (but not all) of the children who were able to phoneme segment, and who knew the letter sounds, could use their knowledge to decode unfamiliar words. Byrne and Fielding-Barnsley (1991) suggest that this implies that phonological awareness and letter/sound knowledge in combination are necessary but not sufficient for acquisition of the alphabetic principal.

Another programme which included grapheme-phoneme knowledge in its facilitation programme was that reported by Torgesen, Wagner and Rashotte (1994). They studied 60 preschool children deemed to be at risk of reading failure and a comparison group of 40 children (said to be 'similar'). The experimental children had a 12 week training programme consisting of 20 minute sessions, four times per week, in small groups. The content of the programme consisted of phoneme synthesis (blending) and analysis (segmentation) tasks. Additionally, towards the end of the programme, the subjects were taught to use these skills to read a small number of real words.

Torgesen, Wagner and Rashotte (1994) argue that the facilitation programme was successful in terms of mean differences between the treatment and control groups, with the experimental group outperforming the control group on phoneme segmentation and blending tasks. However, there was marked inter subject variability with 30% of the experimental children obtaining a score of two or less on the segmentation post-test. Torgesen, Wagner and Rashotte (1994) suggest that response to training can be predicted best by two measures; a measure of invented spelling (requiring phonological awareness and letter sound knowledge) and a measure of rapid naming of digits (see section 3.2.6. for a further discussion of the evidence provided by performance on serial naming tasks). Further, Torgesen, Wagner and Rashotte (1994) argue that the children who benefit most from such a facilitation programme are those with the highest metaphonological skills. Blachman (1994a) advises caution in drawing such conclusions from current knowledge arguing that they could result in the children most in need of such programmes being excluded from them.

Blachman (1994b) carried out a study to explore further the influence of facilitating grapheme-phoneme correspondence skills. Cossu, Rossini and Marshall (1993) had suggested that the promising results of facilitation studies such as that of Bradley and Bryant (1983) could be explained solely in terms of the emphasis on letter-sound knowledge. Blachman (1994b) investigated whether facilitating letter-sound knowledge alone can influence literacy skills. She compared three groups; one having no interaction; one having training in metaphonological processing and grapheme-phoneme links; and the third having an identical letter-sound programme to the second, but having practice in general linguistic processing. The three groups were initially identical in terms of sex, race, socio-economic status, vocabulary skills, letter sound knowledge and reading ability. The intervention groups received training four times per week, for 15-20 minutes, for seven weeks.

Blachman (1994b) found that the children in the group which had training in both phonological awareness and letter-sound knowledge significantly out performed the other two groups on measures of phonological awareness, reading and spelling. Blachman (1994b) argued that these results support the hypothesis that it is a combination of metaphonological and grapheme-phoneme skills which influences early literacy development.

1.6.2.2. Enhancing speech processing skills through developing phonological awareness

A rather different facilitation study is reported by Howell and Dean (1994). In a series of 13 single case studies of phonologically disordered children (3 girls and 9 boys) aged between 3;7 and 4;7 (mean 4;1) years Howell and Dean found evidence that an intervention programme designed to develop metaphonological skills had led to significant change. The pre-testing involved two tests of phonological awareness (phoneme segmentation and acceptability judgement) and two metasyntactic control tests (sentence segmentation and sentence acceptability judgements) deemed unlikely to be affected by the facilitation programme.

The intervention was given for 30 minutes, once per week, for periods averaging 10 weeks (the amount was not standard as it depended on the response of the phonologically disordered subject to therapy). The content of the programme involved games designed to allow the child to explore the properties of sounds, and specifically speech sounds, in an interactive way (see Howell and Dean (1994) for a fuller description of the intervention programme). The programme is termed Metaphon therapy.

Howell and Dean (1994) found that there was significant change on both the metaphonological tasks and on one of the metasyntactic tasks, sentence segmentation. This outcome meant that it was not possible to argue that the effects of the metaphonological facilitation programme were specific to phonological awareness. However, Howell and Dean (1994) hypothesise that the results may reflect a poor choice of control task with the intervention programme influencing segmentation skills as well as phonological awareness. While the sentence segmentation task had been designed as a measure of word awareness, it can be argued that what was in fact measured was the ability to segment the speech stream into a series of units; a skill that might be expected to be facilitated by a training programme such as the Metaphon approach.

1.6.2.3. The assumption of stability

In general, facilitation studies have been based on an implicit premise that metaphonological skills are stable and enduring abilities, and that children with good phonological awareness at, for example, four years old, will remain as skilled in relation to their peers one year later. Without such knowledge it cannot be assumed that training metaphonological skills will be an economic use of resources. If, for example, a child who has relatively poor phonological awareness at four years old will, through development alone, become highly aware (as compared to his peers) one year later, what would be the purpose of intervening?

Knowledge of the inherent stability of metaphonological skills would appear to be a prerequisite for the advocacy of facilitation programmes. However, Blachman (1994) proposes a radically different view . She argues that the findings of stability of phonological processing (see section 1.7.) could be interpreted as a contraindication for the establishment of training programmes. Blachman suggests that any demonstrable stability of metaphonological processing might make altering that ability very difficult. she argues that evidence of stability of individual differences in metaphonological skills could be taken as evidence that these skills would be resistant to change.

1.7. IS PHONOLOGICAL AWARENESS A STABLE ENTITY?

There have been few longitudinal studies of the development of phonological awareness in the absence of facilitation (see sections 6.2.1. & 6.2.2.). However, there is some evidence from cross sectional studies (see for example, Torgesen, Wagner and Rashotte, 1994; Wagner, Torgesen, Laughon, Simmons and Rashotte, 1993). Wagner, Torgesen et al (1993) argue that phonological processing abilities should be viewed as stable, coherent, individual variables similar to other cognitive abilities. From their study of 184 preschool and young school age children (see section 3.2.6. for a fuller discussion of this study), Wagner, Torgesen et al (1993) provide evidence of marked similarities between pre-readers and readers in the underlying relationship between influential phonological processing abilities.

If it is true that metaphonological abilities are coherent and stable, then it follows that it might be beneficial if children who might be expected to have persisting, poor phonological awareness could be identified in early childhood. Further, if the link between metaphonological skills and literacy (see sections 2.3.4.5. and 3.5.3.) is accepted, then facilitation programmes could be advocated to try to enhance early metaphonological skills in readiness for literacy. However, if it is also accepted that the stability of phonological awareness (if confirmed) may be a contraindication to the success of a training programme then attention has to be paid to the optimum form and content of that programme.

The studies summarised in section 1.6.2 appear to suggest that training in phonological awareness in combination with letter/sound knowledge is the most effective approach. However, following the work of Wagner, Torgesen and their colleagues (Torgesen, Wagner and Rashotte, 1994; Wagner, Torgesen, Laughon, Simmons and Rashotte, 1993) further explication of the nature and the role of the underlying competencies relevant to the development of phonological awareness (as discussed in Chapter 3) would allow a more principled approach to the design of a curriculum for a facilitation programme.

1.8. SUMMARY

This chapter has reviewed observational and experimental evidence of the developmental changes that occur in metaphonological skills during the preschool years, and of the possibility of facilitating such change. The progression from awareness of syllables, through intrasyllabic units to awareness of phonemic segments has been discussed. This profile of metaphonological processing informs the theoretical rationale underpinning the assessment of phonological awareness designed for the current study (see section 4.7). The aim was to devise an assessment which would reflect the metaphonological processing skills of children aged both four and five. Such an assessment, in which change over time can be monitored, is essential to the study of the nature of phonological awareness.

The aims of the current study are to undertake both an evaluation of the contribution of influencing variables to metaphonological processing, and to compare changes in phonological awareness over time for a cohort of children tested at four years old and then one year later. The review of the literature undertaken in Chapter 1 has highlighted the important influence of age on metaphonological processing. Within the current study, age will be controlled with all children being tested within one month of their birthdays. It is intended that one outcome of this study will be enhanced knowledge of the nature, and correlates of phonological awareness in four and five year old children.

The evidence reported in this chapter supports the hypothesis that children younger than five years of age do demonstrate awareness of phonological form. Another outcome of the current study will be a better understanding of the age at which children with poor phonological awareness can be identified. This information, taken together with the detailed evidence of the nature of phonological awareness provided by this study, will allow the content of any facilitation programme to be tailored to the needs of children of particular ages, and would enhance interpretation of individual subject's response to the programme.

Chapter 2 discusses current hypotheses about the interrelationship between cognition, literacy and phonological awareness. Literacy skills are generally introduced at around the same age as the significant cognitive changes cited as being related to linguistic awareness, for example decentering (Pratt and Grieve, 1984; Bialystok, 1986), or growth in information processing capacity allowing two pieces of information to be processed simultaneously (Hirschfield, 1989; Galambos and Goldin-Meadow, 1990; Stuart, 1990). It seems eminently sensible that such cognitive skills and environmental influences should be implicated in the development of linguistic awareness, but other evidence suggests that such cognitive changes, whilst being important, are not a sufficient explanation. There is clear evidence that differing linguistic experiences, for example, bilingualism (Galambos and Goldin-Meadow, 1990; Pattnaik and Mohanty, 1984), language impairment (Howell, 1989; Howell and Dean, 1994; Kahmi, Lee and Nelson, 1985; Magnusson, 1991; Magnusson and Naucler, 1990; 1993; Meline and Brackin, 1987; Warrick and Rubin, 1992), illiteracy (Bertelson, de Gelder, Tfouni and Morais, 1989; Goswami and Bryant, 1990) and hearing impairment (Gartner, Trehub and Mackay-Soroka) have a bearing on the development of phonological awareness. Chapter 2 presents an analysis of the current evidence of the interrelationship between cognitive and linguistic factors in the development of linguistic awareness, providing a basis for the current study.

CHAPTER 2

The nature and correlates of phonological awareness

2.1. INTRODUCTION

The debate about the nature, correlates, and effects of phonological awareness is vigorous. One of the difficulties in drawing any conclusions from published studies is that few focus specifically on phonological awareness. Many include metaphonological skills within a more general discussion of linguistic awareness including metasyntactic, metasemantic and metacommunicative processing. In the absence of a substantial body of literature specifically devoted to phonological awareness, the findings of studies of more general linguistic awareness have to be taken into account in forming hypotheses about children's ability to reflect upon the sound system of language. However, indications are all that can be gained from studies which, in the light of current knowledge, often have a poorly defined concept of the different facets of linguistic awareness. Further, any implications drawn from the study of linguistic awareness can only be very tentatively related to the development of phonological awareness, due to the currently limited understanding of the relationship between different aspects of metalinguistic processing. For example, it is by no means clear that a child who displays poor phonological awareness will also have more difficulty than his peers on tests of syntactic awareness.

The poorly maintained distinction between levels of linguistic awareness is reflected in the studies which explore the relationship between metalinguistic and linguistic processing. This chapter will review published studies both of phonological awareness and of the more general skill 'linguistic awareness', so as to form a basis for investigation of a specific aspect of the relationship between linguistic awareness and linguistic skills, namely; the relationship between phonological awareness and phonological processing skills (see Chapter 3).

Two of the central questions, concerning linguistic awareness, addressed in this thesis are

1. the nature of the behaviours which constitute linguistic awareness
2. the extent to which linguistic awareness is governed by
   a. metacognitive processes, or
   b. linguistic skills.

These two questions are inter-linked. Researchers who have put forward models of the cognitive processes underlying the development of metalinguistic processing have distinguished between unconscious and conscious (Tul'viste, 1986); implicit and explicit (Karmiloff-Smith, 1986; Galambos and Goldin-Meadow, 1990; Tyler, 1991), tacit or reflective (Grieve, 1990) or epilinguistic and metalinguistic (Gombert, 1992) awareness. The argument is that conscious, explicit (metalinguistic) awareness develops later than unconscious, implicit (epilinguistic) abilities, thus attempting to account for the evidence (from the observations of, for example, Weir, 1962; Clark, 1978; Kucsak, 1983) that children of three years old, and younger are, at some level, 'aware' of the sound structure of their language. However, the relationship is not a simple one of chronological development as illustrated by Bertelson and de Gelder's (1991) intriguing report of an adult, illiterate, Portuguese poet who could produce many examples of rhymes but could make no explicit judgements, despite much encouragement, about the 'part' that the rhyming items had in common.

2.2. THE RELATIONSHIP BETWEEN PHONOLOGICAL AWARENESS AND COGNITIVE PROCESSING.

2.2.1. The contribution of Piagetian theory

Some of the earliest papers to link metalinguistic and cognitive skills went beyond a generalised developmental description (as outlined in section 1.3.) and argued that linguistic awareness depended upon the child attaining the level of concrete operational thought (for example, Sinclair, 1978; Hakes, 1980; Van Kleek, 1982). (See Van Kleek (1994) for a comprehensive analysis of the contribution of Piagetian theory to the field of metalinguistics.) However, on detailed examination, the Piagetian model did not lend itself readily to parallels in the field of linguistic awareness (Elliot 1983). Specifically, it had difficulty reconciling evidence that children as young as three years old could participate in some metalinguistic tasks, with the theory that concrete operational thought develops in middle childhood (Bowey and Patel, 1988).

Donaldson and Elliot (1990) argue that the reason that Piagetian theorists overestimated the age at which children could participate in metaphonological tasks might be the fact that these researchers generally used only experimental tasks to estimate the child's level of cognitive functioning. Donaldson and Elliot's argument is supported by the findings of a study carried out by Van Kleek and Bryant (Van Kleek, 1994) in which eight children aged 1;6 to 2;4 years were observed to display metalinguistic behaviours that, according to Piagetian theory would have required a level of concrete operational thought, well before they reached the appropriate age.

Van Kleek (1994) employed a cross-sectional design to study metalinguistic and cognitive (conservation) skills in 30 children aged between 4;6 and 7;0 years. While this study found significant correlations between these abilities, the argument that conservation skills were a necessary precursor to the development of linguistic awareness was weakened by the finding that a subgroup of six subjects with poor conservation skills had good metalinguistic ability. Van Kleek (1994) argues that a child's cognitive level, predicted by Piagetian tasks, will not always predict a child's level of metalinguistic processing.

A general conclusion, drawn by those theorists who argued that metalinguistic ability presupposes cognitive control, was that information processing theories might provide a more useful model of the cognitive processing underlying linguistic awareness (see, for example, Abrahamsen, 1982; Gombert, 1992; Friel-Patti, 1994).

2.2.2. The contribution of information processing models

Information processing models assume that processing can best be described in terms of mechanisms for encoding, interpreting, storing and accessing information. Some models have been conceived primarily in terms of sequential processing (see for example, Kay, Lesser and Coltheart, 1992); others have stressed parallel, distributed, processing networks (for an overview see McClelland, Rumelhart and the PDP Research Group, 1986).

The nature of the individual processing components, and of the processing mechanisms, is a matter of active debate (Friel-Patti, 1994). However, there is acceptance that linguistic evidence from the environment influences change within the processing system. Lahey and Bloom (1994) argue that change in a system which involves both storage and processing components can come about in two ways. First, physical maturation can lead to increased speed of processing, and also to increased capacity. Second, increased efficiency of processing (through, for example, automatisation of routines) can free processing resources leading to change, not in absolute, but in effective processing capacity. The importance of increasing absolute, and/or effective, capacity is that this reduces the necessity for trade-off between processing demands, preventing performance in one area suffering because another, more problematic, area has required additional processing resources (Crystal, 1987; Lahey and Bloom, 1994)

Formulating one of the first of these models (EMMA), Marshall and Morton (1978) postulated the existence of an error detection mechanism within the language processing system. The operation of such a system is argued to give rise to awareness; detection of errors being a necessary pre-requisite for their identification and correction. The type of reflection made possible by a mechanism such as EMMA is at the relatively low level of implicit awareness and the model would find it difficult to account for the implicit/explicit distinction recognised by so many researchers in the field. Further, the model has been criticised as being error driven. Karmiloff-Smith (1986) has argued persuasively that it is success and not failure which brings about increased knowledge and skill within development.

Karmiloff-Smith (1986) proposes four successive levels of functioning in the development of linguistic awareness which are characterised by different types of cognitive representations.

- Implicit knowledge. This is the knowledge that underlies the child's first linguistic competencies. Its components cannot be accessed and operated upon separately; the procedure can only 'run' in its totality.
- Primary explicitation (primary explicit knowledge (Gombert, 1992). The implicit knowledge undergoes reorganisation into some form of system but is structured in terms of the same representational code (i.e. spatial, kinaesthetic, linguistic) as the implicit knowledge from which it derives. The knowledge is still not available for conscious access.
- Secondary explicitation (Secondary explicit knowledge). The information remains in the same representational code but is available for conscious access.
- Tertiary explicitation (Tertiary explicit knowledge). The knowledge is reorganised into a more abstract code so that it is possible for the knowledge to be coded linguistically and therefore verbalised.

The implication of this model is that it is possible for children to have implicit knowledge which might 'drive' functioning (for example, repair behaviours) but not be accessible to the subject's consciousness. Karmiloff-Smith (1986) addresses the question of developmental progression by arguing for a three phase recursive model which allows a child, at any one time, to be at different levels for different aspects of awareness.

- Phase 1 - in which the production of an individual linguistic form is dependent on external factors and driven by behavioural success. The representations of that form are stored independently of all others.

- Phase 2 - in which the implicit knowledge accumulated during the first phase is organised. The errors and approximations seen during development arise, according to Karmiloff-Smith, because the progression to explicit knowledge is accompanied by a loss of information, and because metaprocedural organisation imposes a greater cognitive burden than automatic activation of a form.
- Phase 3 - like Phase 1, also depends on procedural success with the links established during Phase 2 being reconsidered in the light of external stimuli. At this phase conscious access (secondary and tertiary explicitation) becomes possible.

'These are recursive cycles of processes which repeat themselves for each aspect of the linguistic system during overall development' (Gombert, 1992; p185). Gombert accepts Karmiloff-Smith's (1986) model as having 'great explanatory power' but argues that its 'bottom-up' nature (starting with individual events and building them into a system) has limitations. He also suggests that there are inconsistencies which are difficult to resolve in the close association of stages which either do, or don't, depend on the influence of external factors. Further, he argues that postulating an unrelated path through these phases for individual linguistic functions implies separate detectors for each function which would signal when performance had reached the necessary level of stability for progression to the next phase.

Gombert (1992) proposes an alternative model, based on Karmiloff-Smith's (1986) work, which conceptualises linguistic awareness as developing over four successive phases:

1. Phase 1. The acquisition of the first linguistic skills.

   This phase is, in essence, the same as the first phase of Karmiloff-Smith's (1986) model. However, the acquisition of these skills is seen to encompass not only production but also comprehension; indeed, processing in its entirety. Further, Gombert argues that not only positive, but also negative, feedback determines the end of this phase and the beginning of the next.

> ' ...the reappearance of errors where previous linguistic behaviour was always correctly adapted is thus not (or at least not solely) the consequence of the progression to a higher level of cognitive functioning but is rather partly the cause of it. These errors occur because, in contrast to what an overly local analysis seems to suggest, the child is required to resolve increasingly complex problems of communication as the model with which it is provided increasingly requires the interaction of different linguistic forms.' (Gombert, 1992; p188)

2. Phase 2. The acquisition of epilinguistic control

   The difference between this phase and Karmiloff-Smith's second phase lies in the conception of development as being both the control of implicit knowledge gained in Phase 1 and also the potential linking of this knowledge to other, new, knowledge concerning the same form or associated forms. A second difference is that Gombert perceives that the external context also has an influence at this level. He argues that the epilinguistic detection of ungrammaticality might depend either on the recognition of dissonance (related to previously associated contexts) or on the child not comprehending the utterance. With the development of a 'rule system' for the linguistic form concerned, the child gradually acquires the ability to refer to this as the phase progresses. 'The establishment of a stable pragmatic reference point for each linguistic form is the principal characteristic of the phase' (Gombert, 1992. p189)

3. Phase 3. The acquisition of metalinguistic awareness

   The epilinguistic control gained at phase 2 forms the basis for conscious awareness in Phase 3. In the latter phase consciousness of awareness is optional in Gombert's (1992) model; the trigger being necessity for the conscious knowledge and intentional control. Such a necessity arises, for example, during literacy training or in pre-literacy facilitation programmes. 'In this case early metalinguistic awareness seems to facilitate the acquisition of abilities which, being necessary to this awareness, then stimulate it in their turn.' (Gombert, 1992. p190)

   The consequence of the optional nature of linguistic awareness within this phase is that some linguistic abilities are never submitted to this level of control or reflection. The high cognitive load of conscious control means that not all linguistic skills become the subject of reflection at the same time. The usefulness of awareness of a particular function, its complexity and frequency within the language all contribute to the discrepancy between the development of linguistic awareness in different areas.

At this level the distinction between knowledge of language and control of the application of that knowledge becomes important. Gombert (1992) argues that metalinguistic knowledge precedes metalinguistic control and the application of that knowledge.

4. Phase 4. The automation of the metaprocesses

   To reduce the burden of 'meta-functioning' metalinguistic processing becomes automated. Automated processes differ from epilinguistic processes in that they are always available to conscious access and will be so if the automatic functioning of linguistic processing is interrupted for any reason.

The models suggested by Karmiloff-Smith (1986) and Gombert (1992) are valuable in that they account for the distinction between implicit and explicit awareness noted in many studies. In addition, these models allow conceptualisation of the type of cognitive operations which might underlie developing metalinguistic (metaphonological) awareness. However, despite Gombert's reference to internal representation during Phase 2, and his discussion of the way in which language skills can 'trigger' linguistic awareness during Phase 3, these models do not offer an easily accessible way of accounting for the complex interaction found in many studies between linguistic processing (such as literacy, bilingualism, and language disorder) and developing level(s) of linguistic awareness.

2.2.3. The emergence of different levels of linguistic awareness

In a study representative of recent work which has sought to explain the developmental progression observed in terms of the potential contributing skills, Galambos and Goldin-

Meadow (1990) argued (within the context of grammatical processing) that there is a verbal continuum based on the explicitness of awareness of language, the end point being overt verbalised metalinguistic judgements. The levels of task investigated by Galambos and Goldin-Meadow (1990) were;

- noting the errors in ungrammatical sentences
- correcting these errors
- explaining why the errors were wrong.

Galambos and Goldin-Meadow (1990) chose these tasks because they argue that these reflect a continuum from implicit to explicit knowledge about the language required to perform each task correctly. Discussing the abilities involved at each level, they suggest that the ability to note errors might only require a type of unconscious error detecting mechanism such as those proposed by Marshall and Morton (1978), and Karmiloff-Smith (1986).

Galambos and Goldin-Meadow argue that the ability to correct errors is more complex; requiring detection of the error as well as the ability to process the ungrammatical construction exhaustively, and retain it in short term memory long enough to generate a correct sentence associated with the incorrect form. Galambos and Goldin-Meadow (1990) propose that an unconscious error detector that leaves no trace in short term memory cannot readily account for this ability.

Arguably, the most explicit metalinguistic ability is the ability to explain an error. In addition to the skills required to note and correct, the child must also demonstrate explicit and articulate knowledge of the rules underlying, for example, the corrected sentence. Galambos and Goldin-Meadow suggest that the tasks of deleting, correcting and explaining ungrammaticalities appear to differ systematically in the level of explicit knowledge required to perform each task, and that both the abilities to correct, and to explain, errors would appear to require a more complex explanation than that offered by the model of an unconscious error detection mechanism.

2.2.4. The structuring and control of analysed knowledge

2.2.4.1. The contribution of the model

A, potentially, more fruitful understanding of the interactions involved can be gained from study of the model proposed by Bialystok and Ryan (1985a) who made a distinction between different levels of linguistic awareness in terms of both the level of knowledge available (implicit/explicit) and the control of this knowledge. Indeed, Bialystok and Ryan's (1985b) primary intention in proposing their model was to examine the nature of linguistic awareness and its relationship to other language processing abilities. Bialystok and Ryan (1985a) argue that their evidence suggests that children respond systematically to metalinguistic tasks, even at five years of age. Their claim is contradictory (in common with Karmiloff-Smith (1986) and Gombert (1992) to that of models in which linguistic awareness is described as a 'revolution' occurring at around seven years of age (when the child is said to attain the level of concrete operational thought), or after literacy training begins. Such a notion of linguistic awareness is replaced by a

> 'description of continuing development in which analysed concepts of language can be intentionally applied under a variety of contextual demands'. (Bialystok, 1986, p508)

Bialystok and Ryan (1985a) argue that if common underlying skills can be identified, correlations in performance can be explained by the interaction of those skills. They suggest that two skills, the structuring and control of analysed knowledge, have a central role in a matrix which models the developmental progression of linguistic awareness reported in the literature (see Chapter 1 for a discussion of this developmental progression).

The notion of analysed knowledge has its roots in description from both epistemology and psychology which distinguish between forms of knowing. Bialystok and Ryan (1985a) make the distinction between knowing that is intuitive and knowing that is explicit, or objective. Often these categories have been presented as a dichotomy. Bialystok and Ryan's (1985a) contribution is to place these forms of knowing on a continuum.

> 'Development, then, is the emergence of the more analysed forms through the increasing ability to structure and classify knowledge'.
> Bialystok and Ryan, 1985a. p233)

Increasing values on the high/low analysed knowledge dimension reflect the learner's increasing ability to represent the structure of language in addition to its meaning. In Bialystok and Ryan's (1985a) model a correction task requires a greater degree of analysed knowledge than does a judgement task whilst making similar demands on control.

The dimension that Bialystok and Ryan (1985a) term 'cognitive control' is closely allied with the notions of "executive functioning ' and 'working memory'. Control involves the selection and co-ordination of information usually within time constraints. In metaphonological tasks there is an increasing need to retrieve information about form as opposed to meaning. Since meaning is the salient aspect of the linguistic message, deliberate focus upon certain formal parts of the message is difficult

> 'It is the ability ......to know what information is required, to retrieve it, and to co-ordinate it into a solution within given time constraints that is the responsibility of cognitive control'
> (Bialystok and Ryan, 1985a. p235)

The demand for control can be decreased (e. g. by providing prompts) or increased (for example

1. When a sentence repetition task contains slightly deviant sentences and additional control is needed to suppress the natural tendency to normalise the sentence and pay attention only to the form.
2. If the type of information necessary to the solution is not immediately obvious.
3. If there is a compelling alternative to the formal knowledge usually necessary for the solution.)

There is a certain interdependency of the dimensions of control and analysed knowledge; when problems require the control function to retrieve specific aspects of formal information, then the required mental representation must be sufficiently analysed. However, there is also independence as illustrated by the observation that having the analysed representations does not guarantee that the learner can utilise them in response to problems.

2.2.4.2. Evidence from experimental and field studies

It is useful to return to Galambos and Goldin-Meadow's (1990) findings and to consider them in the light of the model proposed by Bialystok and Ryan (1985a). (For a fuller description of Galambos and Goldin-Meadow's (1990) study, see section 2.3.2.5. which discusses the influence of bilingualism on phonological awareness). Galambos and Goldin-Meadow looked for content-, versus form-, based approaches to language at each of the levels of language awareness assessed (detecting, correcting and explaining grammatical errors). They studied children aged from 4;0 to 8;0 and concluded that even the youngest children in the sample could detect errors, and thus attend to form independently of meaning. Their findings suggested that the child's approach to detection of error is initially content (or meaning) oriented and only later form-based. An alternative explanation (Howell, personal communication) might be that as the children could not interpret meaning from the ungrammatical sentences, they were compelled to focus on form.

Galambos and Goldin-Meadow (1990) concluded that there was a similar content to form based approach in the corrections the children produced. The pre-kindergarten children often had a content-based orientation whereas the kindergarten and 1st grade children were almost exclusively grammar oriented. The younger children in this group gave grammar oriented corrections based on awareness of isolated linguistic markers whereas the older children gave grammar oriented corrections based on awareness of a more complete system. The developmental progression appears to be from an approach to language based on content, to an approach based on linguistic markers, to an orientation focused on linguistic systems. This sequence first occurs for the detection of error, then for corrections, and finally for explanations.

Such differences in linguistic awareness can be characterised within Bialystok and Ryan's (1985a) dimensions of analysed knowledge and control. Bialystok and Ryan argue that the difference between judging grammaticality, locating an error, correcting an error and stating the rule involved is that these problems have increasing values on the dimension 'analysed knowledge' and cite evidence from other studies to support this claim. Similarly, segmenting speech into syllables, words and phonemes (which have been shown (see section 1.3.) to be of increasing difficulty for children) involves increasing values of analysed knowledge; specifically, intact phonological representations.

Karmiloff-Smith (1986) made a similar observation. She found a developmental progression from sensitivity to extra-linguistic cues, to sensitivity to intra-linguistic cues based on markers, to sensitivity to intra-linguistic cues based on systems. Karmiloff-Smith found this progression first in spontaneous repairs and then in explanations. The conclusion must be that at any one time the child's skills cannot be described in terms of a single 'approach' (in Galambos and Goldin-Meadow's (1990) terminology to language; performance depends on the level of linguistic awareness being tapped and on the progress the child has made from a content-based to a form-based approach.

However, the developmental path seems to lead to different outcomes (in terms of types of grammatical construction) at each level of awareness. In Galambos and Goldin-Meadow's (1990) study, grammatical constructions that children found easy to correct were distinct from those that were most easily explained. This suggests that, contrary to Bialystok and Ryan's (1985a) notion of a continuum, detection and correction might rely on different underlying skills from explanation.

Further evidence that detection/correction might not form an absolute continuum comes from studies of bilingual subjects. In 1985 (a. & b.) Bialystok and Ryan suggested that bilingualism appears to be related to accelerating control because speakers of more than one language are more generally aware of the separability of form and meaning. They are therefore more able to operate upon these aspects separately for any level of analysed knowledge.

However, Galambos and Goldin-Meadow (1990) present additional data which required a modification of Bialystok and Ryan's (1985a) framework. Galambos and Goldin-Meadow argue that by 4;6 years bilingual children have differentiated two language systems and have developed automatised procedures for attending to the forms of their language. The process of automating a procedure permits conscious access to that procedure in a wide range of environments, and could thus account for children's heightened attention to the form of language.

Section 2.3.2. below provides a fuller discussion of the influence of bilingualism on the cognitive operations underlying linguistic awareness, illustrating the inter-relationship between the cognitive and linguistic factors which influence metalanguage, and specifically metaphonology.

2.3. THE RELATIONSHIP BETWEEN PHONOLOGICAL AWARENESS AND LINGUISTIC PROCESSING

2.3.1. Introduction

Galambos and Goldin-Meadow's (1990) work illustrates the need to consider not only the contribution of cognitive functioning to the development of metalinguistic or metaphonological skills but also linguistic influences. Whilst there is debate about the relationship between linguistic and metalinguistic processing, this chapter presents evidence that 'non standard' language development, whether at the level of primary, second or secondary (literacy) language learning, influences phonological awareness. This evidence is drawn from studies of bilingualism, language disorder, illiteracy and the acquisition of literacy.

2.3.2. Phonological awareness and bilingualism

2.3.2.1. Bilingualism: Observational studies

Some of the earliest papers concerning linguistic awareness documented the effect of exposure to different languages, and commented upon the possible influence such linguistic experiences might have on the development of awareness of linguistic form and content. Lundberg (1978) cites observations by Ianco-Worrall (1972) that a group of bilingual children separated sounds from meaning in words earlier than a matched group of monolingual children and argues that this performance indicates an awareness that a single referent can have more than one phonological realisation.

Slobin (1978) presents fascinating examples of linguistic awareness observed in his pre-school child, Heida, between the ages of 2;9 and 3;11. Her comments concerned both the meaning and form of words and at one stage demonstrated not only the ability to segment but also a link between awareness of phonological form and awareness of meaning.

> ' (3;1) Heida asks:" *Cookie*. What does *cook* mean?" When given an answer she went on to ask "What does *ku* mean?" (Slobin, 1978. p47.)

Clark (1978) suggests that learning two languages at once might heighten the ability to reflect on both, and thus further increase intrapersonal variation in levels of linguistic awareness.

2.3.2.2. Bilingualism: Experimental studies

Pattnaik and Mohanty (1984) studied 3 groups of 20 bilingual and 20 monolingual children aged 6+, 8+, and 10+. The subjects were Kond tribal children from the Orissa district of east India who spoke Oriya and Kui, or Oriya alone. The children all came from the same social background (as measured by parental income and level of parental education (lower primary)). Both the bilingual and unilingual Konds shared the same cultural background with the only difference being the language used. The children were given Piagetian conservation tasks, a non verbal test of intellectual functioning and metalinguistic ability tests. These are not specified in the text but are said to derive from the work of Clark (1978).

Pattnaik and Mohanty's (1984) findings indicated a significant effect of bilingualism on performance on metalinguistic tasks, but not on the tasks of conservation or of nonverbal reasoning. The authors argue that this outcome is due to the fact that bilingual children who have the ability to switch from one code to another develop the ability to reflect on language regardless of the level of their cognitive development. They suggest that metalinguistic abilities constitute a set of skills which can be conceptualised independently of cognitive abilities per se. However, the link between metalanguage and the cognitive processes (discussed in section 2.2.) supporting such awareness is more complex than such a conclusion might suggest.

2.3.2.3. Bilingualism and literacy

Tunmer and Myhill (1984), reviewing the literature on linguistic awareness and bilingualism, argue that bilingualism facilitates increased metacognitive and metacommunicative abilities which, in turn, influence the development of literacy skills and therefore academic achievement. Tunmer and Myhill (1984) suggest that a possible explanation for this inter-relationship is that, in the process of becoming bilingual, children develop a more analytical orientation to linguistic structures in order to separate the two target languages into functionally independent systems. Thus, they acquire higher levels of metacognitive functioning as cognitive control is necessary to perform these metalinguistic operations.

2.3.2.4. The effect of bilingualism on the language processing system

Galambos and Goldin-Meadow (1990) argue, based on their review of the literature, that until they are two years old, children exposed to two languages appear generally to have only one linguistic system that develops in the same way as that of monolingual children; the difference being that the bilingual child's system includes features of both language models. During the third year the single code gradually separates into two, with the phonological aspects of the code generally being separated first, followed by the lexical and then syntactic aspects. By the ages of three to four years old, bilingual children begin to realise that they speak two distinct languages, and within that period begin to comment explicitly.

Hirschfield (1989) proposes an interesting 'domain specific conceptual device', that ranges over societal concepts, as a potential explanation for the bilingual child's ability to distinguish between multiple languages. In his argument the device

> "allows the young child to assign a partially represented novel term to a structured and inferentially rich array of hypotheses about the nature of human groups." (Hirschfield, 1989. p234)

2.3.2.5. Bilingualism: Levels of awareness

Galambos and Goldin-Meadow (1990) suggest that learning to differentiate two language codes necessarily entails extensive attention (initially unconscious, later explicit) to the form of language. Such an ability requires both the development of procedures for accomplishing this differentiation, and the automation of those procedures so that they become available to conscious access. They argue that these procedures for dealing with form (which are not necessarily required by monolingual children) could be the foundation for the explicit judgements about form which bilingual children demonstrate.

Galambos and Goldin-Meadow (1990) studied 32 Spanish speaking and 32 English speaking monolinguals and 32 Spanish/English bilingual subjects aged 4;5 to 8;0. They administered a test which included 15 different ungrammatical constructions and 15 grammatically correct items. The subjects were asked to judge whether the sentence was correct or not, to correct any error noted and to explain why those errors were wrong. Galambos and Goldin-Meadow found that the bilingual children noted more errors than the monolingual children in Spanish sentences (in which both groups were equally proficient) and the same number of errors in English (in which the bilinguals were less proficient). In Spanish and English the bilinguals produced more grammatical corrections, for the errors they noted, than the monolinguals whose corrections tended to focus on content. The authors concluded that the bilingual children had an advantage over the monolingual with respect to noting and correcting errors. However, this advantage did not hold for the ability to explain the errors, suggesting that the experience of learning two languages enhances the development of only a subset of metalinguistic skills.

Galambos and Goldin-Meadow (1990) conclude that although the bilingual experience appears to hasten a child's progress away from a content-based approach (allowing attention to form as well as meaning; a higher level of control) at all the levels of awareness (detecting, correcting, explaining) it does not appear to alter what the child knows about language (the level of analysed knowledge) at any of these levels. To this extent, their conclusions support Bialystok and Ryan's (1985a; 1985b) prediction that it is in cognitive control that bilingual children have their greatest advantage and that metalinguistic tasks requiring the highest levels of control should best reflect the superiority of bilingual children.

Bialystok (1986) studied 119 children from urban, working class, schools with large immigrant populations. The children were approximately equally divided amongst three age levels; five, seven and nine years old. Approximately half the children at each age level were fluent in a language other than English, but were all judged to be as fluent in English as the monolinguals. 12 different languages were spoken by the subjects.

A judgement correction task was administered involving four different types of sentence; grammatical meaningful (GM), ungrammatical meaningful (gM), grammatical anomalous (Gm) and ungrammatical anomalous (gm). Bialystok (1986) hypothesised, first, that the demand for analysed knowledge is increased when sentences are ungrammatical since more explicit or analysed structures are required; and second, that the demand for control is increased when meaning must be ignored since meaning is processed quickly and automatically. Thus the GM sentences are, hypothetically, the simplest in that they make minimal demands on the two skills. The gm sentences are only more difficult in that more explicit knowledge structures are required to detect errors in ungrammaticality. The gM sentences do not place high demands on control (since meaning is present) but challenge analysed knowledge in the detection of grammaticality. The Gm sentences, however, place a primary burden on control processes. Bialystok (1986) hypothesises that the difference between performance on gM and Gm sentences should illuminate the influence of bilingualism on metalinguistic processing. Bialystok found that the two factors which affected the children's ability were age (which influenced the level of analysed knowledge) and bilingualism (whose primary effect was seen on control of linguistic processing). Bialystok (1986) concluded that monolingual and bilingual children have different levels of cognitive control for metalinguistic tasks.

However, Galambos and Goldin-Meadow (1990) suggest that increasing attention to form (presumably made possible by the automatised procedures for dealing with form) does not automatically lead to form-based explanations; although it may lead to the avoidance of meaning based explanations. In order actively to produce a form-based explanation the child must be able to understand and articulate the violation underlying an error in a grammatical construction; an ability which does not appear to be heightened merely by the automation of processing procedures engendered by the bilingual experience.

Galambos and Goldin-Meadow (1990) discuss arguments which link the late appearance of explanations to the child's ability to reason and explain in general, and suggest that the ability to attend to more than one dimension at once is a necessary but not a sufficient pre-requisite for the ability to generate the most advanced corrections and explanations. Galambos and Goldin-Meadow's (1990) argument is based on the fact that whilst there is evidence (Collins, Berndt and Hess, 1974; Flavell, 1977; Piaget, 1978; Siegler, 1984) that suggests that being able to consider more than one aspect simultaneously is characteristic of children aged over six years, all ages of children in their study were able to provide some explanations. What differed between the older and younger children was the ability to give explanations based on the grammatical form of a sentence rather than the meaning.

Galambos and Goldin-Meadow cite Karmiloff-Smith (1986) in support of their conclusion that the ability to attend to more than one aspect at once is necessary, but not sufficient, to account for the more complex explanations and corrections found in the data. Karmiloff-Smith (1986) suggests that a recurring process of re-description in the child's internal representation of language is responsible for the ever increasing conscious access the child has to the formal characteristics of his language. Restructuring refers to the process of unifying the implicitly represented isolated procedures underlying a child's correct usage of a linguistic construction into a system. She argues that it is this type of restructuring (rather than an 'adding to') the internal representation of language which makes possible conscious access of the form and organisation of language; insight which is reflected in tasks tapping linguistic awareness.

Following Karmiloff-Smith (1986), Galambos and Goldin-Meadow (1990) suggest that it is the recurrent re-description of the information a child processes which accounts for the developmental progression from detecting to correcting to explaining errors. They argue, further, that experience of two languages appears to restructure the child's internal representation into two distinct systems. Bilingualism leads to increased awareness but not to increased ability to abstract rules. Restructuring appears to facilitate detection and correction but does not affect conscious access to the linguistic facts about the language one speaks. Although restucturing may hasten progress from a content-based to a form-base approach to language at all levels, it does not alter the types of constructions the child can master at any level. Thus, bilingual experience may awaken a speaker's attention to the form of his language, but not enough to restructure what he knows about the two languages.

2.3.2.6. Summary

Overall, the studies discussed in this section provide evidence for a link between the experience of bilingualism and the development of linguistic awareness and illuminate the potential nature of the cognitive operations which support the ability to make metalinguistic judgements. The parallel importance of the underlying knowledge/representations, and of the ability to access and manipulate these, is beginning to become clear.

2.3.3. Phonological awareness and language disorder

2.3.3.1. Introduction

Whilst authors such as Kahmi (1987) have attempted to address the question of whether language impaired children have specific or more generalised/pervasive problems in reflecting on language, their analyses are hampered by the generality of the definitions of language impairment adopted, particularly in their lack of reference to the specific nature of the language processing difficulties. For example, in Kahmi's (1987) study a child was judged to be language impaired if they

a. performed one year or one standard deviation below age level on measures on expressive and receptive language.

b. performed within normal limits on a non-verbal rest of intelligence.

c. had no indications of severe emotional disturbance or physical or sensory deficits.

Such a definition would result in children with different, underlying, profiles of linguistic functioning being involved in one study. The current thesis argues that definitive results will only be obtained by comparing specific levels of linguistic processing with awareness of those levels; in the current study these are phonological processing skills and metaphonological abilities. However, it is necessary to draw briefly upon the wider field of study to establish the case for later, specific, discussion of phonological and metaphonological processing.

2.3.3.2. Metaphonology and language disorder: evidence from segmentation studies

Kahmi, Lee and Nelson (1985) studied 15 language impaired children (mean age 5;8), 15 mental age matched (mean age 5;7) and 15 language age matched (mean age 3;0) subjects. Each group included 8 boys and 7 girls. Kahmi, Lee and Nelson (1985) adapted Fox and Routh's procedure; asking the children to divide sentences into words, and words into syllable and sound units. The language impaired children performed at a significantly lower level than the mental age, and language age, matched controls. Over half the language impaired children could not begin to divide sentences or bisyllabic words.

Kahmi, Lee and Nelson (1985) then used an adaptation of Papandropoulou and Sinclair's (1974) task, asking the children 'What is a word? Say a long/short, easy/hard word.' The language impaired children's performance was significantly poorer than the mental age matched controls, but there were no significant differences between the language impaired subjects and the language matched controls. Kahmi, Lee and Nelson argue that their findings suggest that language impaired children's metalinguistic difficulty is not limited to making grammatical judgements but that they also have difficulty segmenting sentences and words into their constituent units. Kahmi, Lee and Nelson (1985) return to Kahmi and Koenig's (1985) argument that not only may language impaired children have difficulty acquiring knowledge about the linguistic elements that form part of words, they may also have difficulty accessing that knowledge. This conclusion avoids the question of the quality of the internal representations available for accessing. (see section 3.2.6. for a discussion of the interrelationship between accessing and store of phonological units, and sections 3.2.4. & 3.4.3. for a discussion of the development of the phonological system.)

In the study by Warrick and Rubin (1992; see section 2.3.3.7.) a group of language disordered and a group of normally developing children were compared on a range of tests of phonological awareness including rhyming, and phoneme manipulation and segmentation. The language disordered group performed at a lower level on all these tasks, except on one segmentation task (an initial phoneme isolation task where the child had to prolong and then isolate the initial phoneme) and a phoneme manipulation task (in which the child had to manipulate any phoneme in a word to make it 'silly'). Interestingly, however, the phonologically disordered children made different manipulations to the normally developing children; avoiding substitutions and deleting or adding phonemes instead.

Whilst the language disordered children always performed at a lower level than the normal group the fact that there were only significant differences for some individual tasks led Warrick and Rubin (1992) to suggest that the tasks required different levels of 'explicitness' of linguistic analysis. The language disordered children's performance appeared to be able to be profiled on a similar hierarchy of explicitness as the normal children but to generally to be at a lower level.. Warrick and Rubin's notion of 'explicitness' could perhaps be illuminated in the light of, for example, Bialystok and Ryan's (1985a) concepts of the structuring and control of analysed knowledge (see section 2.2.4.).

2.3.3.3. Communicative awareness and language disorder: response to listener needs

Fey and Leonard (1984) investigated language disordered children's ability to adjust their output in response to perceived listener needs. They found that language impaired children could make similar adjustments to their speech to toddlers, peers and adults as same age, normally developing children, but were not so able to alter syntactic form. In a conference paper reported by Kahmi (1987) Lee, Kahmi, and Nelson looked at the ability of language impaired children to assign specific utterances to listener roles i.e.. to decide whether a particular sentence would be most likely to be said by a child, a father or a mother. (It would appear questionable whether this task actually assessed the ability to assign specific utterances to listener roles or to *speaker* roles.) The language impaired children made significantly more errors assigning listener roles based on semantic cues than did the language age matched and mental age matched controls. When all the sentences were read by an adult male voice the language impaired children were more likely than the normally developing children to be influenced by the vocal characteristics of the reader; i. e. to decide that the sentence would be said by a 'father' despite the semantic content.

Kahmi (1987) concludes that language impaired children are sensitive to the stylistic variations appropriate when speaking to younger children, peers, and adults but that they have difficulty in using semantic and syntactic information to assign utterances to appropriate listener roles and that these difficulties arise from their language processing restrictions.

2.3.3.4. Communicative awareness and language disorder: spontaneous repair strategies

Kahmi (1987) found no studies which looked specifically at the spontaneous (self initiated) repairs of language impaired children despite evidence that younger children spontaneously make phonological repairs, and that older children make self-initiated syntactic, morphological and lexical repairs.

Kahmi (1987) suggests that the fact that language impaired children make a large number of speech/language errors may make them less likely to detect an error in their own output when it occurs. Further, he argues that if language impaired children were able to detect and correct errors in their own speech, communicative effectiveness would not necessarily be enhanced; frequent repair might lead to a decrease in communicative efficiency. However, Kahmi (1987) provides no evidence to support these suggestions and there would seem to be other competing explanations; for example that the ability to detect or to correct errors may depend on the specific nature of the language processing disorder.

2.3.3.5. Communicative awareness and language disorder: response to clarification requests

Gallagher and Darnton (1978) looked at elicited repairs; responses to the neutral query 'what?'. Their subjects included 12 language impaired children at each of Brown's (1973) developmental language stages I, II, and III. The mean age of the stage I children was 3;6

and of stage III, 5;4. Gallagher and Darnton (1978) found that language impaired children's response to the 'what?' query was as frequent as that of language stage matched, normally developing children. However, the types of revisions produced by the language impaired children showed a clear developmental progression not seen in the performance of the language impaired children. Gallagher and Darnton (1978) concluded that language impaired children are sensitive to the communication demands of queries but lack the linguistic knowledge (for example, of semantic and syntactic equivalencies) to produce more sophisticated revisions.

Kahmi and Koenig (1985) designed a study to test a similar hypothesis; that, in a test of detection of phonological, syntactic and semantic anomalies, language impaired subjects would identify fewer errors than normals and would also have more difficulty correcting the errors they identified. Kahmi and Koenig studied 10 language impaired children (7 male) and 10 (6 male) mental age matched children. All subjects were aged between 4;0 and 7;2. The language impairment was defined by testing on assessments of semantic and syntactic functioning and by the diagnosis of a speech language pathologist. No information was given about the phonological skills of the language disordered children. All the children performed within normal limits on an assessment of nonverbal intelligence. The subjects were asked to identify and correct the error in sentences containing syntactic, semantic or phonological errors. For example, the set of phonologically anomalous items the subjects were asked to respond to included sentences such as 'Susan's dicycle is in the garage'.

Kahmi and Koenig (1985) found that the language impaired children had considerable difficulty in identifying and correcting syntactic errors but performed as well as the age matched controls in detecting and correcting semantic (both groups were able to do this) and phonological (both groups had problems) errors. These results require clarification of the relationship between the specific nature of the speech language processing disorder and the outcome, and in accounting for the memory load imposed by the task format which required processing at sentence level and retention of the resulting information. As suggested in section 2.3.3.6. it could be hypothesised that a language impaired child whose disorder was manifest primarily at the level of syntax processing would perform very differently on such a task from a child with a predominantly semantic processing difficulty.

2.3.3.6. Communicative awareness and language disorder: Making clarification requests

What is known about the ability of language impaired children to make requests for clarification? Kahmi (1987) concludes that the literature is confusing. Fey and Leonard (1983) report findings that language impaired children make less frequent clarification requests than same age normally developing children. Lee, Kahmi and Nelson (1983) presented 10 unintelligible sentences (within the context of a 30 minute play session) to 15 language impaired and 30 normally developing children aged 3;0 to 6;0. The language impaired children made fewer clarification requests than either the age matched or language age matched groups. Typically, the language impaired children either ignored the utterance, or nodded without seeming to have understood. The authors argued that the findings suggest that language impaired children assume it is their fault if they do not understand. This conclusion is supported by the study of 15 language impaired school age children, 15 age matched controls and 15 language (comprehension) matched children carried out by Meline and Brackin (1987). The language impaired children had a mean age of 8;2 (SD 5.07). Meline and Brackin (1987) used a story context in which the 'speaker' made a request, which was too general so that the intention could not be understood. Subjects were classified as 'speaker-' or 'listener-' blamers on the basis of their response to the examiner's questions. In contrast to the age matched controls, the language impaired and younger children, were predominantly listener- blamers who had difficulty in realising that messages that are too general are inadequate because of the speaker's failure to specify the request.

However, Kahmi (1987) cites some studies which have indicated that there is no difference in the frequency and type of clarification requests made by language impaired children (for example, Griffin, 1979 (unpublished thesis); Fey and Leonard, 1984). Leonard (1986) studied language impaired children aged between 2;0 and 3;6 and found that the language impaired children made more requests for repetition and clarification than their language age matched peers. He attributes this to the greater mental age and comprehension abilities of the language impaired children.

Kahmi (1987) suggests that one reason for the discrepancies between these findings may be the contrast in experimental situations studied and, more specifically, in the nature of the dyads involved i.e. were children talking to 'authority figures' or to peers. Again, a poorly controlled variable is the type of the language processing difficulty. The nature of the task needs to be systematically considered against the specific nature of the child's processing difficulties; for example, whether the disorder lies at the level of syntactic or semantic processing.

2.3.3.7. Communicative awareness and language disorder: Levels of awareness

Warrick and Rubin (1992) focused on the phonological awareness of language disordered children (defined as such by the diagnosis of a speech-language pathologist, a language sample, and performance on tests of vocabulary and of auditory comprehension of syntax). The 13 language disordered subjects were matched for age (mean age 5;4 years), sex, socio-economic background and exposure to the same school curriculum with 15 normally developing subjects (mean age 5;2 years). None of the children had received any formal instruction in reading, they were all monolingual and had no physical, sensory or emotional problems.

Warrick and Rubin (1992) asked their subjects to judge the 'silliness' or otherwise of a sentence in which the sound structure of one word had been altered (for example "Here are some little foys (toys)"). The child was asked to help the experimenter 'fix the silly part' and ultimately to explain what s/he did to 'fix' it. Both groups of children performed equally well on the judgement task and were equally poor at explanation. However, the language disordered children were significantly worse at correcting the errors they judged.

To what extent this difficulty reflected an individual child's pronunciation limitations requires further exploration. If production limitations are irrelevant then it would be tempting to add to Kahmi and Koenig's (1985) conclusion (that language disordered children do not only have difficulty acquiring various forms but also in reflecting on them once they have been acquired) the words *'and also in accessing them'* (i.e. to make corrections). It can be hypothesised that the ability to reflect on the internal representation is not sufficient to allow acceptability judgements to be made; rather the child must also be able to access a relatively stable and complete system of phonological representations (see section 3.2.6.).

An interesting side issue concerns the ability of language disordered children to give explanations for the errors they detect/correct. Whilst Galambos and Goldin-Meadow (1990) found that children aged between 4;5 and 8;0 could make some attempt at explaining the syntactic anomalies that they judged, Howell (1989) and Warrick and Rubin (1992) found that ability to produce explanations within an acceptability judgement task was very low for both normal and linguistically disordered four to five year old children. The argument that the age of the child might be all important is upheld by Rubin, Kantor and Macnab (1990) who found no differences between linguistically disordered (age range 8;2 to 12;4) and language age matched (6;3 to 6;11) children's ability to produce explanations; it was the older children within each group who could produce some explanation. The role of factors such as linguistic maturity seems supported by Galambos and Goldin-Meadow's finding that bilingual children who outperform monolingual children on some metalinguistic tasks have no advantage when required to produce explanations during anomaly judgement tasks (see section 2.3.2.5.). This evidence suggests that the increased linguistic awareness of the bilingual children is not sufficient to influence performance on anomaly judgement tasks. It may be that performance on such tasks is influenced by a combination of factors such as age, which does not only have an effect through increasing maturity but also through increasing opportunities for exposure to formal language teaching.

It is evident from this review of the literature that there is a clear link between language development and linguistic awareness. The interrelationship appears complex but evidence of a specific link between language processing skills and metaphonological abilities is beginning to emerge. The next evidence of the interconnection comes from the literature concerning linguistic awareness and literacy.

2.3.4. Phonological awareness and literacy

2.3.4.1. Introduction

One of the primary motivations for the study of linguistic awareness in general, and phonological awareness in particular, has been the link that has been established between reading difficulties and poor linguistic awareness. (For an excellent review of the pre-1990 literature see Goswami and Bryant, 1990.) The papers can be grouped into several distinct areas; studies which attempt to link different aspects of linguistic awareness with pre-literate and literate functioning, evidence about the linguistic awareness of illiterate subjects, evidence of the metalinguistic skills of school age children who are poor readers, longitudinal studies covering either the pre-school to school years or early to later school years, and studies which look directly at the relationship between metalinguistic, linguistic and cognitive functioning and reading skills.

2.3.4.2. Studies of pre-readers: issues of timing

One of the most interesting questions raised by the overall body of research on linguistic awareness and literacy has been the extent to which the development of phonological awareness precedes, or follows, reading instruction. As discussed in section 1.3., many studies (Weir, 1962; Slobin, 1978; Clark, 1978; Chaney, 1992) have shown that well before the start of school many children demonstrate the ability to be aware of the sound structure of their language. Other studies (Bradley and Bryant, 1983; Bryant, Bradley, MacLean and Crossland, 1989; Bowey and Francis, 1991) have provided evidence that children's performance on these tasks is strongly predictive of later reading skills even after other variables, such as intellectual level, are partialled out of the equation.

Bryant, Bradley, MacLean and Crossland (1989) studied 64 children aged between 3;4 and 6;3 years and found that there was a strong relationship between early knowledge of nursery rhymes and success in reading and spelling over the next three years, even after differences in intellectual level, phonological awareness at outset of the project and social background were taken into account.

Similar results were obtained by Bowey and Francis (1991) who studied 60 preliterate children; 20 from kindergarten (mean age 5;5), and the 20 youngest (mean age 5;8) and the twenty oldest (mean age 6;5) from first grade. However, the report of the study does not mention control of factors such as intellectual level or social background. The kindergarten children were equivalent to the younger first grade children in terms of verbal maturity but, unlike the school children, had not been exposed to reading instruction. The younger first grade children were less linguistically mature than the older subjects but had had the same exposure to reading instruction. On tasks of onset, rime and phoneme oddity both first grade groups performed at an equivalent level, and above the kindergarten group. In all groups, onset and rime tasks were of equal difficulty but phoneme oddity tasks were more difficult than the rime oddity tasks. None of the kindergarten children performed above chance on the phoneme oddity task. Further analysis of the data from the school age children indicated that performance on onset/rime judgement tasks explained variation in early reading achievement more reliably than phoneme oddity tasks.

Earlier studies which had appeared to indicate that a more general phonological awareness was related to later reading skills, could be re-analysed in the light of insights into the existence of intra-syllabic units such as onset and rime (see section 1.3.2.). For example, Kirtley, Bryant, MacLean and Bradley (1989) used a sequence of studies to demonstrate that the original oddity tasks used by Bradley and Bryant (1983) were in fact tapping rime/onset knowledge rather than knowledge about individual phonemes.

Why should pre-school ability to be aware of rime influence later reading skills? Goswami and Mead (1992) argue that the link may be related to children's awareness of spelling sequences in words. Based on the finding that children use orthographic analogies between the spelling pattern of words to help in decoding novel words (i.e. reading 'bat' by linking it with 'cat') (Goswami, 1990) Goswami and Mead (1992) hypothesise that onset/rime measures would show a strong and specific relationship to orthographic analogies between the ends of words but that performance on measures on syllable and phoneme awareness would not. They studied the performance of 44 children aged 6-7 years (mean 6;9, range 6;3 to 7;7) on two reading tests, a vocabulary measure, tests of letter sounds and letter name knowledge, two analogy tasks and assessments of phonological awareness.

Goswami and Mead (1992) found partial support for their hypothesis in that they found a significant relationship between measures of onset and rime even after controlling for real word, and nonsense word, reading ability. However, the relationship between awareness and analogy judgement was stronger for rime than for onset awareness. Goswami and Mead (1992) suggest that one possible explanation for their findings is that children only use beginning analogies in reading when they can detect phonemes. Thus, whilst analogies based on rime could be performed before children begin reading instruction, an explanation supported by Bryant, Bradley, MacLean, and Crossland (1989), if the literature on the acquisition of phoneme awareness is accepted (see section 1.3.3.) children would only use beginning analogies as a result of reading. The premise about analogy, on which such hypotheses are based, is supported by studies such as that of Bowey (1990b) that provide evidence that syllable onset and rime units serve as functional units of reading.

2.3.4.3. Studies of illiterate subjects

The inter-relationship between literacy and phonological awareness can also be explored by considering evidence from studies of subjects who are illiterate. Such investigations have been carried out in countries (for e.g. Portugal and Brazil) where the later introduction of comprehensive educational programmes has meant that it is possible to find adults who have not been exposed to reading instruction.

Morais, Cary, Alegria and Bertelson (1979) studied a group of illiterate subjects, and a matched control group of readers. The results suggested that whilst the illiterate group had some success overall, they were poorer than the literate group on tasks involving adding and deleting phonemes from real and nonsense words.

In 1989, Bertelson, de Gelder, Tfouni and Morais reported results from a study of literate and illiterate subjects in Brazil. They found that while the illiterate subjects had some success on tasks of vowel deletion (from VCV or VCVC structures) and rime judgement, they performed poorly on tasks of phoneme deletion. These findings suggest that illiterate subjects may have awareness of some phonological units but that awareness of phonemes is particularly difficult in the absence of script knowledge.

Further evidence (Morais, 1991b) of an investigation of an illiterate Portuguese poet indicates that there may also be differences in the level of awareness attainable by illiterate adults. The subject was able to generate rhyming words with ease but not to comment on the way in which rhymes were similar to the target item. It could be argued that explicit awareness depends to some extent on formal educational experiences.

Interestingly, in the context of this thesis, Morais, Clutyens, Alegria and Content (1986; cited by Goswami and Bryant, 1990) demonstrated that there was evidence that illiterate subjects who had difficulty with phoneme segmentation tasks performed as well as a control group on a musical segmentation task. This suggests that any difficulties with the metaphonological tasks were language specific and not dependent on cognitive processing skills.

2.3.4.4. Studies of readers: making predictions

What do studies of readers contribute to this debate about the relationship between linguistic awareness and literacy? Dreher and Zenge's (1990) study of 98 children (mean age 6;1) concluded that linguistic awareness skills demonstrated in the first year at school were a significant predictor of student's reading comprehension performance in both the 3rd and 5th years of school, even when the effect of academic achievement was partialled out.

Carlisle and Normanbhoy (1993) attempted to separate the effects of phonological and morphological awareness on the reading skills of first grade children. They hypothesised that morphological awareness, which has been found to be related to reading achievement for older students (Torneus 1990) might offer a more comprehensive measure of language awareness; arguing that morphological awareness subsumes aspects of both phonological awareness and other linguistic knowledge. Carlisle and Normanbhoy (1993) studied 115 monolingual children from the state schools of one city. The children (59 boys and 42 girls) had a mean age of 6;9 years (range 5;11 to 7;9). Carlisle and Normanbhoy (1993) found that phonological and morphological awareness both contributed significantly to word reading, although the contribution of phonological awareness was the greater. Carlisle and Normanbhoy (1993) question the role of phonological awareness at the early stage of reading acquisition but do not consider their results in the light of the onset/rime analogy which may have improved both the experimental design and helped the authors to account for their findings.

In an earlier study, Tunmer, Herriman and Nesdale (1988) followed 118 children for two years from the beginning of the first school year. They studied metalinguistic ability, pre-reading and reading skills, and measures of intellectual ability. Whilst also not considering their tasks and results within the framework of intra-syllabic units they came to the conclusion that linguistic awareness helps children to realise that print "maps" onto the structural features of language. Tunmer, Herriman and Nesdale (1988) make the interesting, additional suggestion, that some level of phonological ability is necessary for children to acquire grapheme-phoneme conversion skills. Further, they discuss the reason why some children do develop phonological awareness skills during their first year and some do not, concluding that this depends on part upon their level of "concrete operativity". This conclusion, in the light of the argument the current thesis is making, appears rather simplistic. However, it serves to highlight a direction some workers in this field are taking.

2.3.4.5. Studies of readers: intercorrelations between metalinguistic, linguistic and cognitive processing

Another group of studies have questioned whether metalinguistic ability is an independent factor or whether it is related to other cognitive or linguistic skills. Bowey and Patel (1988) explored the conceptual status of linguistic awareness to determine whether metalinguistic ability can account for variation in early reading achievement independently of more general language abilities. The authors argue that there are so many indications in the literature that linguistic awareness is related to language processing skills (see section 2.3.3.) that they cannot concur with studies which suggest that the ability to reflect on language is related primarily to the level of cognitive processing (for example, Hakes, 1980; Tunmer and Herriman, 1984) or even with accounts that imply a stronger relationship between cognitive and metalinguistic processing than between linguistic and metalinguistic skills. Bowey and Patel (1988) suggest that one of the reasons that studies of reading (for example, Bradley and Bryant, 1983; Lundberg, Olofsson and Wall, 1980) conclude that linguistic awareness accounts for a small percentage of the variation in reading ability over and above that explained by linguistic processing is the 'possible insensitivity of many of the measures used to control general language ability' (p370). They argue that it is conceivable that (with carefully chosen measures of language processing allowing statistical control of their effects) it might be found that metalinguistic skills do not have an effect on reading performance which is independent of language processing ability.

Bowey and Patel (1988) chose to measure language abilities using a vocabulary and a sentence imitation test. Their assessment battery also included tests of phoneme categorisation, syntactic awareness, general linguistic ability and reading. Intellectual level was not measured. They studied 60 (predominantly middle class) children with a mean age of 6;1 years (range 5;6 - 7;0); 34 girls and 26 boys. Bowey and Patel (1988) found a significant relationship between the two metalinguistic tests and the children's reading levels but argued that, when general language ability effects were controlled, the two metalinguistic measures accounted for less than 1% of the variation in early reading achievement; a result that was no longer significant.

Bowey and Patel (1988) argue, therefore, that the hypothesis that metalinguistic ability accounts for the variation in early reading achievement independently of general linguistic ability effects (when the language tests are carefully chosen) receives no support. The two linguistic tests were significantly related to the children's reading performance, even after the effects of the two metalinguistic tasks were controlled, contrasting with the findings of previous studies (e.g. Bradley and Bryant, 1983; Lundberg, Olofsson and Wall, 1980; Bowey, 1986a/b). The authors suggest that this discrepancy is not due to a lower correlation between metalinguistic and reading measures in this work, but to the more effective control of general language ability factors.

Bryant, MacLean and Bradley (1990) expressed reservations about Bowey and Patel's (1988) study; notably that the children were relatively old (and there is evidence that the relationship between scores of rime awareness and reading tend to be low in the performance of children aged 6 years and older), and that the study was not longitudinal but relied on correlational statistics. Bryant, MacLean and Bradley (1990) designed a longitudinal study to overcome these perceived methodological difficulties. They aimed first, to explore the relationship between children's metaphonological skills and progress in reading and, second, to investigate whether this is a specific connection or whether a perceived effect is merely a by-product of general language ability.

Bryant, MacLean and Bradley (1990) involved 65 subjects (31 boys, 34 girls) from a wide range of backgrounds. 64 were native English speakers. At the time of first testing the average age was 3;4 (range 2;10-3;9). At last testing the average age had risen to 6;7 (range 5;9-6;10). Bryant, MacLean and Bradley (1990) report data from six testing sessions carried out over the three years. The consequence of this longitudinal testing was that, at different ages, the children completed different test batteries. For example the linguistic measures administered to the children at 3;4 were a vocabulary test (Dunn, Dunn, Whetton and Pintilie, 1982) and a test of expressive and receptive language (Reynell, 1977). At 4;11 the children were given a sentence imitation test. Linguistic awareness was assessed at 4;7 on tests of rhyme and alliteration oddity and syntax awareness tasks. At 4;5 the children's reading abilities were screened to check for precocious readers and at 6;7 two standardised reading tests and a spelling test were given. Intellectual functioning was measured at 4;3 with a short version of the Wechsler Intelligence Scales for Children (Wechsler, 1974) being carried out at 6;7.

Bryant, MacLean and Bradley (1990) carried out fixed order multiple regressions that partial out the influence of differences in intelligence before charting the relationship between the linguistic and metalinguistic scores and reading. They found that correlations between the linguistic and metalinguistic measures were quite high but that the correlation between the metalinguistic variables and the reading/spelling measures were higher than the correlation between the language measures and reading and spelling, suggesting that rhyme and alliteration abilities are related to reading and spelling even after controlling for differences in linguistic functioning. The intellectual level scores correlated well with linguistic, metalinguistic and reading and spelling scores and the authors argued that any relationship between linguistic, or metalinguistic, measures and reading could be attributed to the variance that the linguistic and metalinguistic variables share with intelligence.

Following Bowey and Patel's (1988) procedure, Bryant, MacLean and Bradley (1990) ran the first set of multiple regressions without entering IQ or social background scores. The outcome was similar to Bowey and Patel's (1988) in that the linguistic measures predicted reading well. However, after differences in general linguistic abilities had been partialled out in a subsequent regression analysis, all three metalinguistic scores still predicted reading performance.

Bryant, MacLean and Bradley (1990) included intelligence and social background scores in the second regression analysis to ensure that the relationships found in the first regression analysis were not merely a by-product of differences in these extraneous variables. The outcome showed striking differences to the first analysis. First, intelligence and social background accounted for a large proportion of the variance. Second, the linguistic variables were no longer good predictors of reading and spelling, only accounting for a small proportion of the variance. Similarly, syntax awareness, a good predictor of reading and spelling in the first regression, accounted for hardly any of the variance. However, rhyme and alliteration withstood the effect of partialling out differences in social background, intelligence and general language abilities well accounting for a significant proportion of the variance in all three outcome measures.

Bryant, MacLean and Bradley (1990) conclude that there is a strong connection between four year old children's sensitivity to rhyme, to alliteration and to syntax and their reading two years later which cannot be explained away as a 'mere symptom' of a more general linguistic ability. They argue that connections previously found between linguistic measures and reading simply reflect differences in social background or intelligence. Bryant, MacLean and Bradley (1990) argue that a combination of the variables social background, intelligence, and sensitivity to rhyme and alliteration accounted for an 'impressive' amount of the variance in the subject's reading and spelling abilities.

Bryant, MacLean and Bradley (1990) suggest that possible explanations for the discrepancy between their own and Bowey and Patel's (1988) results are, first, that Bowey and Patel's tests of rhyme were given to six year olds and Bryant's to four year olds. At four years old it is possible to get a relatively 'pure' measure of ability to categorise words by sounds because the child is not yet reading. Thus 'when the test is given to pre-school children, one is measuring their ability to form categories that will help them to read later on, but when it is given to older children one might be picking up effects of the experience of reading as well.' (Bryant, MacLean and Bradley, 1990. p250) The authors preferred this explanation but suggested that a second possibility is that the difference in results might be due to the difference in form of tests of alliteration and rhyme. Bryant et al (1990) suggest that their tests might have been an easier version. However, as neither test suffered from floor or ceiling effects is difficult to see why an easier test should be a better predictor of reading than a harder one unless additional uncontrolled variables contributed to success. Bowey (1990a) argues that the discrepancy between the findings of her study and that of Bryant and colleagues is relatively minor and could be the result of sample size given the number of independent variables.

Some support for Bowey's overall stance is provided by an investigation carried out by Chaney (1992) in which she examined the correlations between early metalinguistic skills, language development and emergent literacy knowledge (see also section 3.5.1.). Chaney studied 43 children with a mean age of 3;8 (range 2;9-4;2); 22 boys and 21 girls. The selection criteria stated that the children should be monolingual, have normal hearing, and normal language development. Chaney tested the children on a battery of linguistic (including a general assessment of language development, articulation, auditory discrimination vocabulary, and syntax), metalanguage (including tests of metaphonology (phoneme judgement and correction, rhyme/initial sound identification and production, phonological play and phoneme synthesis tasks) metamorphology, and metasyntax, and reading performance tests. No measure of cognitive functioning was included .

Chaney (1992) found, contrary to expectations, that correlations between specific domains and their metalinguistic counterparts were not significant. Low scores on the articulation test were not reliable predictors of low score in phonological awareness. Scores on the linguistic measures were all highly correlated apart from articulation and auditory discrimination which, Chaney argued, appeared to be two relatively independent skills. This is not entirely surprising as auditory, or speech, processing skills might not be expected to be processed in a similar way to that in which language is processed. Print awareness was highly correlated with overall linguistic awareness, and specifically with phonological awareness, when the effects of age were partialed out. Family income was not a significant predictor of overall linguistic awareness but was related to scores on the reading tasks.

Chaney (1992) concluded that overall proficiency in language development is the best predictor of overall metalinguistic performance and that language development, linguistic awareness and print concepts were significantly intercorrelated with print awareness being most strongly related to phonological awareness. Chaney's results are, however difficult to interpret because, like Bowey and Patel (1988) she does not control for differences in intellectual functioning. The dangers of this are amply illustrated by Bryant, MacLean and Bradley (1990), and discussed above (this section).

Bryant, MacLean and Bradley (1990) also raise the issue of the confusion between phoneme and rhyme awareness apparent in Bowey and Patel's study. It is noteworthy, in the context of this thesis, that both studies compared tests of onset, rime and phoneme awareness with tests of linguistic functioning in a range of other areas including syntax and vocabulary. Bowey and Patel's original argument, and Bowey's (1990a) comment, that future replication requires to employ more specific tests of linguistic functioning seem self evident if the relationship between linguistic awareness and linguistic processing is to be illuminated. The current thesis aims to address some of these methodological issues by comparing metaphonological processing with the relevant level of linguistic processing; i.e. phonological processing abilities.

2.3.5. The contribution of other aspects of phonological processing

Bowey (1990a) also comments that future studies need to consider such factors as verbal memory. The suggestion that phonological memory might have a part to play not just in the development of phonological awareness but also of reading and vocabulary has been in evidence for some time but, until recently, has not been a strong focus in the literature on phonological awareness (see section 6.3).

Holligan and Johnston (1988) investigated the utilisation of phonological information by poor readers and concluded that whilst poor readers might have a phonological disorder in some aspects of reading, this is unrelated to phonological memory capacity. They suggest that poor phonological awareness might underlie subjects' difficulties with both the reading and memory tasks.

This supported a suggestion made by Snowling, Goulandris, Bowlby and Howell (1986) that, when compared with aged-matched and reading ability matched controls, dyslexic children have difficulty with non-lexical procedures (including phonological segmentation) involved in verbal repetition. A consequence of this deficit is hypothesised to be an increased time to process novel words with a consequent effect on verbal memory and reading procedures.

Felton and Brown (1990) explored this interrelationship further and suggested that, for clarity, the term "phonological processes" could profitably be broken down into 3 processes that have been identified as being related to reading:

1. Phonological awareness.
2. Phonological recoding in lexical access.
3. Phonetic recoding in working memory.

Felton and Brown studied 81 kindergarten children with the aim of investigating the relationship between these 3 forms of phonological processing. The children were deemed to be at risk of reading difficulty on the basis of a reading readiness assessment. All the children were English speaking. There were 51 males and 30 females with a mean age of 6;2 years. The authors found no relationship between the three types of phonological processes they had identified, and concluded that there was no evidence of the existence of a general phonological processing ability. However, drawing conclusions about the correlation of any of these phonological processes with reading ability is difficult as some of the children in the study had intensive reading instruction designed to focus on alphabetic code and phonological features thus limiting the value of the results.

Mann and Ditunno (1990) argue that good and poor readers can be differentiated by performance in at least 3 areas:

1. Awareness of phonological structure
2. Retrieval and perception of phonological structures
3. Use of phonetic representations in working memory.

Mann and Ditunno (1990) investigate several questions including; Do phonological deficiencies actually cause reading problems as opposed to being their consequence? When extraneous demands of individual tests are taken into account do phonological deficits remain the best predictors of future reading problems? Mann and Ditunno (1990) argued that all three performance areas predicted future reading problems and that performance on tests of phonological skills is a more consistent and effective predictor of future reading problems than performance on non-linguistic tasks which make similar cognitive demands. The only component of the cognitive testing which predicted reading was a vocabulary test, which the authors argue involves perception and retrieval of phonological structures.

2.4. SUMMARY

This chapter has reviewed evidence for the influence of linguistic and cognitive factors on metalinguistic, and in particular, metaphonological, processing. The review of the literature has highlighted the complex interplay of factors, and the debate as to the relative contribution of individual variables.

Chapter 1 has underlined the importance of controlling for age, if the contribution of other variables to the development of phonological awareness is to be evaluated. Studies which have included children from a wide age range may have influenced their findings in undesirable ways as there is evidence that phonological skills develop rapidly during the preschool years. Further, Chapter 1 began to emphasise the importance of taking secondary language learning, specifically the acquisition of literacy, into account when designing an investigation in this field. Not all previous studies have identified those subjects who could read at the time of the investigation. Such skills would influence the picture of metaphonological processing which emerged.

The review of the literature undertaken in Chapter 2 emphasises the need to employ carefully chosen measures of cognitive and linguistic functioning if the individual influence of these factors is to be evaluated. To separate the contribution of these variables it is necessary, for example, to use an assessment of nonverbal cognition; thus avoiding the measurement error inherent in using a measure such as the British Picture Vocabulary Scales (Dunn et al, 1982) to assess both cognitive and linguistic processing; or using an intelligence scale which includes both verbal and nonverbal items. The studies reviewed suggest a complex interaction between linguistic and cognitive functioning in the development of phonological awareness. This thesis aims to explicate that relationship by the use of a comprehensive, but targeted, assessment battery including a nonverbal intelligence scale and specific measures of linguistic (including phonological) processing.

Chapter 2: The nature and correlates of phonological awareness

The evidence from the studies reported in this Chapter indicates a further refinement of methodological design to allow better evaluation of the relationship between the variables which contribute to metaphonological processing. It has been argued that inconclusive evidence about the relationship between linguistic and metalinguistic processing may be related to the fact that some studies have not measured comparable levels of linguistic and metalinguistic processing. For example, performance on tests of phonological awareness has been compared with linguistic skills such as syntactic development. The argument of this thesis is that it will only be possible to evaluate the influence of linguistic factors on metalinguistic processing if comparable levels of each ability are measured. For that reason the focus of the current study is the relationship between metaphonological and phonological processing.

CHAPTER 3

The relationship between phonological processing and phonological awareness

3.1. INTRODUCTION

Having seen in Chapter 2 that, in addition to the link between cognitive abilities and linguistic awareness, there is a relationship between language processing skills and linguistic awareness it is time to narrow the focus of the thesis. The argument is that it will be possible to establish that there is a stronger relationship between linguistic and metalinguistic skills if the measured abilities focus on the same linguistic level. Specifically, for this thesis, the areas of interest are phonological, and metaphonological, processing. The next sections examine the relevant studies of speech processing.

3.2. SPEECH PROCESSING: OVERVIEW

3.2.1. The relationship between perception and production

The emerging emphasis in the field of phonological processing and phonetic production is a consideration of the speech processing system in its entirety rather than a focus on the component parts in isolation. Indeed, much evidence about phonological development has come from studies of acoustic analysis; particularly concerning the relationship between phonetic and phonological skills, and variation in phonetic production in subjects with language disorders (Howell and McCartney, 1990). Historically, the relationship between auditory perception/acoustic processing and phonemic/speech perception has been the subject of much debate (see Tallal and Stark, 1980). Strange and Broen (1980) outlined three possible models;

1. Perception precedes production. The child perceives all contrasts as an adult would but there are major discrepancies between perception and production. In this example the child may distinguish the difference between 'wing' and 'ring' but have a 'rewrite' rule which leads to both 'wing' and 'ring' being produced as 'wing'.

2. Both the child's perception and production differ from the adult model but, at any one time, the child's system is internally consistent. Within this model the child who collapses the distinction between 'wing' and 'ring' in production also fails to perceive the difference between these words.
3. Both perception and production develop gradually over the first few years but perception of a contrast generally precedes production. At first the contrast is neither perceived nor produced, then it is perceived and, finally, both perceived and produced.

In 1985 Stoel-Gammon and Dunn reviewed the literature and suggested the following potential relationships between perceived, stored and produced forms;

- The adult word is perceived correctly and stored in the adult form.
- The adult word is perceived correctly but stored in a simplified form.
- The adult word is incorrectly perceived and stored in that form.
- The child may have two representations, the adult form for comprehension and the production for based on his/her own pronunciation.

3.2.2 Psycholinguistic models of speech processing

More recently, psycholinguistic models of speech processing have distinguished between input processing (decoding the speech signal) and output processing (encoding and articulating speech). They also postulate internal representations for linguistic items; the form(s) in which, for example, phonological information is stored (Stackhouse and Wells, 1993). Some of these models have been restricted to speech processing (for example, Macken, 1980; Hewlett, 1990); others have explored the inter-relationship between speech and language processing (see for example, Waterson, 1987; Stackhouse and Wells, 1993; Kay, Lesser and Coltheart, 1992).

The literature reports two contrasting positions as to the nature of the lexicon(s) (see, for an introduction, Hawkins, 1984; Howell, 1989; Bryan and Howard, 1992). The first postulates that stored representations are identical to adult surface forms. This view is proposed specifically by Smith (1973) and Stampe (1979) who argue that internal representations which are identical to the adult form would account for the child's relatively good performance on tests of speech perception. To account for pronunciation differences, it is proposed that there are a set of context-sensitive phonological realisation rules which are applied to the adult-like internal representation and which are gradually lost as development proceeds.

Many authors have found this theoretical position impossible to defend (for example, Chiat, 1983; Spencer, 1988; Hewlett, 1990) on the basis of evidence from several sources. Some have argued that there is evidence from adult subjects that the lexical representations underlying spoken word recognition are distinct from those used in production (i.e. Bryan and Howard, 1992). Others (for example, Grunwell, 1981) have argued against the proposal that phonological development is the gradual loss and simplification of a rule system. Menyuk, Menn and Silber (1986) present evidence that children retain earlier representations even when they have acquired a more adult version; providing further evidence against models that propose that the child's production is the result of output realisation rules applied to an adult-like internal representation. Further, researchers such as Macken (1980) have shown that there are some phonemic contrasts to which young children are perceptually insensitive.

Those researchers who have argued against phonological representations being a single, modality-independent, lexicon have proposed various models in which dual lexicons are involved, in a modular way, in input and output processing (for example, Spencer, 1988; Hewlett, 1990; Bryan and Howard, 1992; Chiat and Hunt, 1993). Taking Hewlett's model as an exemplar, a dual lexicon model is proposed in which the Input Lexicon contains phonological representations which are perceptually based and reflect the phonological contrasts available to the child when decoding speech (see section 3.2.4 & 3.4.5. for a fuller discussion). The Output Lexicon contains phonological representations which are articulatorily based and which reflect the child's pronunciation skills. The implications of Hewlett's model for this thesis will be discussed further in the section 3.2.4. below.

The proponents of dual lexicon models have argued that postulating the existence of an input and an output lexicon removes the need to claim that the child's mispronunciations are a result of selecting an adult like item from the lexicon and applying one or more simplifying rules to it before it is spoken. Rather, the rules accounting for the child's pronunciation patterns are rules for mapping input lexical representation onto corresponding output lexical representations.

Such models allow a distinction to be drawn between tasks which involve only analysis and manipulation of sensory or motor phenomena from those whose completion requires accessing of internal representations. While modular descriptions have the advantage of clarity it is important to remember that although some subsystems of language may be relatively independent it is unlikely that the entire language processing system is completely modular (Jenkins, 1991). Possibly the most accurate description would reflect interaction and influence between levels (Crystal, 1987) and would consider processing within individual modules in the light of the implications for other parts of the system.

3.2.3 The nature of internal representation

Menn (1994) defines internal representations as being abstract entities which are capable of handling both recognition and production phenomena whereas Vihman, Velleman and McCune (1994) refer to a form of mental storage.

A single lexicon model has no difficulty with the proposition of a unitary system of phonological representations which might underpin both speech perception and production. Many papers, particularly in the field of literacy (see section 6.3.5.) make such an assumption. However, dual lexicon models have to account for the development, and consider the nature, of internal representation within each two lexicons (Bryan and

Howard, 1992; Menn, 1994) Thus, the use of terms such as 'underlying form' (Dinnsen, 1994) and 'phonological processing' (Torgesen, Wagner and Rashotte, 1994) can be argued to be too general; it is important for these models to distinguish between the representational system involved in recognition and that underpinning production.

Stoel-Gammon and Stemberger (1994) argue that currently there is not enough evidence to allow reliable understanding of the nature of internal phonological representation but make the assumption that information about features, segments and syllable units is included.

There is even less information about the way in which the development and change in input and output representations might be linked despite the papers implying such a connection. These publications have originated from many fields e.g. phonological disorder (Stackhouse, 1990; Marion, Sussman, and Marquardt, 1993); phonological memory (Gathercole, Willis, and Baddeley, 1991b; Torgesen, Wagner and Rashotte, 1994) and literacy (Mann and Ditunno, 1990; Blachman, 1994).

Chiat (1994) suggests that the output lexical entry might be less accurate than the child's knowledge of what a word sounds like and Menn (1994) suggests that the notion of 'underlying form', previously taken to refer to stable auditory, or articulatory, representations, now appears to involve aspects of both the input and output modalities.

This view of interactive processing is reflected in the move to replace information processing models with connectionist models which can deal with interactions between different processing elements. Chiat (1994) argues that, whilst 'box and arrow' processing models could be adapted to accommodate the apparent link between input and output phonological processing (evidenced by the literature concerning phonological memory, phonological disorder and literacy; see section 3.5.3.) such modifications would result in artificial and unwieldy models. Chiat advocates the advantages of using a 'connectionist' framework to model the interactions between phonological features in input and output. Such models do not allow the direct mapping of one type of representation onto another but attempt to describe observable phenomena in terms of a connectionist network.

Whilst the development of connectionist models is at an early stage, their stress on the importance of interactions between, and within, language processing levels allows for the conceptualisation of interconnections between auditory, semantic, phonological and articulatory features. The connectionist approach may come to offer an alternative explanation for the findings of studies which have proposed a single, unitary, phonological processing capacity underlying other related skills such as phonological awareness, phonological memory, speech processing and literacy.

3.2.4. How are systems of internal representation established?

A valuable contribution to the nature of the development of internal phonological representations has been made by Waterson's (1987) model; a perceptually biased theory of development. Waterson argues that the phonological forms produced by the young child are based on those parts of the adult model which have the greatest auditory salience for the child and which are also semantically salient. Semantic salience arises from the way adult models are grounded in context - a mother will repeat similar phrases in similar contexts. Waterson (1987) postulates that despite a limited memory span the child recognises a 'sameness' in (parts of) utterances in a similar way that 'sameness' in the environment is recognised, and will respond to these similarities.

Waterson (1987) suggests that the limited memory span of the child will restrict the extent of the focus on the incoming speech signal. She uses data gathered from observational studies to begin to deduce which features, given these processing limitations, are salient for the child. Waterson argues that the child is best able to perceive the broader distinctions, the holistic unit, and the more 'forcefully' produced consonants (p41) such as stop consonants.

Waterson's argument is that the features the child is able to perceive most clearly, and that he is able to produce, form the basis of his/her phonological structures. Further, the differences between the child and adult forms can be explained in terms of the limited perception of the adult forms and the operation of the child's phonological system which results from this limited perception.(see also section 3.2.5. which discusses the link between perception and production).

Hewlett (1990) presents an alternate model of the development of internal representations (see section 3.4.5. for a fuller discussion) which, as in Waterson's theory, acknowledges the importance of perceptual processing. Hewlett proposes that the perceptual representation from the input lexicon is used as the basis for establishing phonological representations in the output lexicon. The perceptual representations of the input lexicon feed into a motor programmer which devises motor plans. Whereas Hewlett has conceptualised internal representations as being in the form of motor plans, Chiat (1994) argues that this results in an incomplete understanding, as internal representation must include other, specifically linguistic, information.

Vihman, Velleman and McCune (1994) have taken a different perspective of the nature of internal representations which has influenced their model of development. They argue that the linguist's concept of internal representation can be related to the psychologist's concept of 'mental representations'. Vihman, Velleman and McCune (1994) propose that, during early development, a familiar context might provide sufficient perceptual support to elicit the one vocal motor scheme associated with the situation. Later, the capacity for phonological internal representation simplifies word production by creating a small set of routines to be followed, thus reducing the attention necessary to perceptual and motoric aspects of each target word.

Vihman, Velleman and McCune (1994) argue that the changes in the system of phonological representation are underpinned by changes in cognitive and articulatory capacity, and by the influence (auditory salience) of the adult model. Marion, Sussman and Marquardt (1993) present clinical evidence (see section 3.2.6.) for a link between overt, and covert, articulations and the retention and coding of novel phonological strings. Menn and Matthei (1992) suggest that, within a connectionist framework, it is necessary to model the emergence of connections between experiences in different modalities (auditory, motor and kinaesthetic) and to specify the precise nature of the representation of those experiences.

3.2.5. Is there evidence of a link between speech perception and speech production abilities?

In general, the accounts of the development and the nature of phonological processing discussed in sections 3.2.3. & 3.2.4. have postulated some form of link between input and output phonological processing. Is there any evidence from experimental studies that such an interrelationship exists?

The view of speech perception as being central to the establishment of stable, complete, phonological representations is supported by a study of the relationship between speech perception and phonological processing skills in adults (Watson and Miller, 1993). Watson and Miller analysed the relationship between auditory perception, phonological processing and reading in 94 undergraduates, 24 of whom had reading difficulties. The hypothesis investigated was that subtle perceptual deficits might lead to the degraded representation of phonological information in memory, with related problems in the retrieval of unstable codes from memory and also problems segmenting words into phonemes. Watson and Miller (1993) found a strong relationship between speech perception and several phonological skills, including short- and long term memory and phoneme segmentation. However, they found no such effect for nonverbal auditory processing suggesting that the effect is specific to speech perception. Watson and Miller (1993) suggest that poor speech perception skills may lead to the establishment of poor phonological representations (see section 3.2.4. for further discussion of the relationship between speech perception and phonological processing).

There is evidence from clinical data that, even in populations presumed to have relatively intact auditory processing skills (or not displaying difficulties on easy tests of discrimination), detailed testing can reveal perceptual deficits which may have implications for output phonological processing and for related linguistic skills such as lexical access.

Constable, Stackhouse and Wells (1994) present interesting case study data from a seven year old child with a persisting language disorder who had a persisting, but subtle, auditory processing deficit. The difficulty was demonstrated by an innovative test (Bridgeman and Snowling, 1988) which involved (same/different) discrimination between pairs in which the sequence of sounds had been altered (i.e. vost/vots) (as opposed to items which differ in one feature (pat/bat). Bridgeman and Snowling (1988) found their test to be similarly sensitive in a study of older speech impaired (dyspraxic) subjects who did not otherwise appear to have auditory discrimination difficulties.

Further evidence comes from a study by Catts (personal communication) who investigated the influence of perceptual skills on the performance on a phoneme oddity task of 30 children aged 5;8 to 6;9 (mean 6;2). None of the children had a history of speech, language or hearing problems. The phonological characteristics of the initial phoneme in the set of items in the oddity task were manipulated such that on eight trials the contrast was maximal; that is, the initial phoneme of the 'odd' item varied from the other two initial phonemes in terms of place and manner of articulation as well as voicing. For the other eight trials the contrast was minimal with the 'odd' and target phonemes differing by only 1 feature, i.e.. place, manner or voicing. Care was taken to ensure the context provided by the rime was as similar as possible in all items.

Catts and colleagues found that whilst the participants did well overall in the oddity task, achieving 70% success, there was a difference in performance between the minimally and maximally contrasted pairs. The children scored significantly better on the maximally contrasted trials, leading Catts to conclude that there was support for the hypothesis that phonological perception influences performance on this phoneme oddity task.

3.2.6. What influence does the system of internal representation have on phonological processing?

Several studies have proposed that internal phonological representations that are incomplete, or fuzzy, will be more difficult to access and will influence phonological processing in such tasks as recognition, repetition and segmentation (see, for example, Marion, Sussman and Marquardt, 1993; Watson and Miller, 1993; Blachman, 1994; Torgesen, Wagner and Rashotte, 1994).

Blachman (1994) suggests that the individual variation among children's abilities on these individual phonological processing variables will influence their response to reading remediation programmes. (See section 1.6.2. for a discussion of facilitation programmes.) Blachman cites rate of accessing of phonological information (that is, retrieval of phonological codes) as being a crucial factor in determining response to reading remediation programmes; arguing that whilst poor phonological awareness might be the factor which influences a child's enrolment in such a programme, a retrieval deficit may be the factor that keeps him/her there. However, as Marion, Sussman and Marquardt (1993) comment, facilitation studies such as that of Torgesen, Wagner and Rashotte (1994) (on which Blachman is commenting) cannot separate the effects of an incomplete phonological system from difficulties accessing that system. Watson and Miller (1993) (see section 3.2.5. for more information about this study) suggest that the influence of impaired speech perception skills may be to lead to unstable, degraded or fuzzy phonological codes which may take longer to access and/or be less useful one retrieved.

Marion, Sussman and Marquardt (1993) report a study of four children diagnosed as having developmental dyspraxia (DAS) and four age and sex matched controls. The diagnosis of developmental dyspraxia was made on the basis that the children had severe articulatory/phonological breakdown. The subjects were aged between five and seven years old. Marion, Sussman and Marquardt (1993) hypothesised that if the DAS subjects' difficulties were due to the lack of the well formed phonological representations necessary to guide motor performance the disorder would also impact upon other language functions which are hypothesised to depend upon an intact system of internal representations. The linguistic function selected for inclusion in the study was auditory processing as represented by a series of rhyming tasks.

Presenting their conclusions, Marion, Sussman and Marquardt (1994) argue that there are four steps in the successful completion of, for example, a rhyme generation task:-

- the auditory processing of the input target sound, and the retention in short term memory
- the accessing of a phonologically based representational system
- the selection from this system of an entity matching the input string
- the use of this phonological match to drive the articulatory output of a rhyming word.

Marion, Sussman and Marquardt drew the preliminary conclusion that, as the DAS children revealed markedly inferior rhyming abilities to the controls, that DAS is a fundamental disorder of the phonological level of language processing which will influence a range of linguistic processing skills. Indeed, they go further in their discussion of the link between speech perception, internal representation and speech output, postulating a neurological substrata which underlies the mapping of phonological structure and phonemic contrasts, and serves both motor speech processing and the processing of input signals.

Wagner, Torgesen, Laughon, Simmons and Rashotte (1993) report a study of the phonological processing abilities of 95 preschool and 89 second grade children. Wagner et al (1993) were interested in the question of the extent to which variables said to involve phonological processing (for example, phonological memory and phonological awareness) were distinct entities rather than one single processing ability; and further, how distinct such abilities were from general cognitive processing skills. Torgesen, Wagner and Rashotte (1994) argue that facilitation programmes aimed at developing phonological awareness must be based on the explicit knowledge of the validity of the concept of metaphonology, as distinct from general processing capacities.

The preschool group in Wagner et al (1993) study had a mean age of 5;11 years (range 5;2 to 7;2) with the school age children having a mean age of 8;1 years (range 6;7 to 9;3). The groups had almost equal numbers of boys and girls and were stated to be largely non minority with 73% white children in both groups and the majority of the remainder being Black American children.

The subjects carried out tests of phoneme analysis (segmentation, elision, deletion and oddity tasks) and phoneme synthesis (blending tasks), together with tests of phonological memory, phonological code retrieval and cognitive ability. The latter included tests also taken to reflect general language processing, for example the vocabulary subtest of the Stanford-Binet Intelligence Scales (Thorndike, Hagen and Sattler, 1986).

The tests profiling retrieval of phonological codes from long term store are of interest as they represent a more recent addition to studies of phonological processing. Wagner et al (1993) present the hypothesis that the efficiency with which children can retrieve the phonological codes associated with individual phonemes, syllables and words will influence the degree to which phonological information is useful in decoding; that is, the children have to have phonological codes available to them *and* to be able to access those codes. Wagner, Torgesen, Laughon, Simmons and Rashotte (1993) assess the efficiency of code retrieval by means of tests of speed of naming digits, and letters, presented individually and in sequence.

Wagner, et al. (1994) used factor analysis techniques to isolate individual processing abilities. The authors argue that their findings suggest that phonological processing is best described as a framework of multiple, correlated, abilities including phonological analysis, phonological synthesis, phonological coding in working memory and retrieval of phonological codes.

The implication of Wagner et al's (1993) findings is that, in studies of phonological awareness, these phonological processing components have to be considered independently, and separately from cognitive (and, arguably, linguistic) skills. In addition, studies of phonological awareness need to be sensitive to the potential interrelationship between perception, representation/coding, and accessing abilities if they are to offer comprehensive explanations of the nature and correlates of metaphonological processing. It is unfortunate that Wagner, Torgesen, Laughon, Simmons and Rashotte's (1993) study did not include assessment of perceptual skills in order that their modelling might have taken account of input processing abilities and/or restrictions. The current thesis includes assessment of perceptual skills and should provide further evidence of the nature of the interrelationship between phonological processing skills, particularly shedding light on the developmental progression; a process argued (see section 3.2.4.) to be highly influenced by perceptual factors.

3.2.7. Units of phonological processing

There is an increasing body of evidence that, initially, children's attention is focused on units larger than the segment, or phoneme, and that the syllable is the basic unit of phonological processing with feature distinctions and/or the phoneme only becoming important later in development and/or as a result of the introduction of literacy (for further exploration of these ideas see Treiman and Breaux, 1982; Menyuk, Menn and Silber, 1986; Waterson, 1987; Fowler, 1991; Morais, 1991b; Bird and Bishop, 1992; Boucher, 1994; and section 1.3.).

Waterson (1987) proposed that the child's first internal representations of words are constructed not on the basis of segments but on the basis of attention to the acoustic patterns of whole words or word groups. Waterson argues that the prosodic characteristics of words (including the number of syllables, the relation of syllables to each other, and the positioning of stress) are more important than the segmental characteristics. Words are treated as 'phonetic wholes' (Hewlett, 1990). Fowler (1991), describes evidence, from three areas, that early word productions are represented as distinct holistic shapes and not systematically related to each other via prosodic and articulatory attributes. The evidence is first, the fact that early phonetic forms appear to be tied to particular utterances and not to be generalised across words; second, observations that the production of individual items is unstable in different contexts and, third, evidence that the production of individual phonemes is more heavily influenced by context than is the case in adult speech.

There is further evidence that, following a word level and a syllable level focus, the child is sensitive to intrasyllabic units before becoming fully aware of phonemes (see sections 1.3.2. & 1.3.3.). Treiman (1988; Treiman and Danis, 1988) proposed the units of onset and rime which extended the concept of intra-syllabic units, Boucher (1994) presents what he argues is a more dynamic view of this level of organisation. Boucher's conception is of serial ordering of featural events being determined by reference to syllable size events which are planned and perceived as units). He argues that this concept does not preclude seriation being organised for larger polysyllabic frameworks, or featural aspects being co-operatively realised. Boucher suggests that this "proposal differs markedly from the rather static conception of the syllable as merely providing slots (e.g. onset, coda, rime) or nodes, for constituents whose position is determined by features ..... of the subunits" (Boucher, 1994, p11.)

Bertleson and de Gelder (1991; see also sections 1.3.2.5.) also extend Treiman's concept of intrasyllabic units by presenting interesting evidence that the onset nucleus sequence also forms a unit; one which has acoustic/phonetic significance. However, their argument is flawed by the experimental design (see Klima, 1991; and section 1.3.2.5. for a discussion) and further investigation of this interesting hypothesis is required.

Waterson (1987) argues that this gradual shift from a syllabic to a segmental focus (1.3.1.4.) is due to the child incorporating features into the internal representation until such representations match the corresponding adult representation. Jusczyk (quoted by Bird and Bishop, 1992) and Fowler (1991) both suggest that the transition from attention to syllables to attention to segments is prompted by increasing vocabulary size. As vocabulary increases some form of order has to be imposed upon it. Jusczyk conjectures that this need for structure stimulates attention to phonemes, as storage organised in terms of the initial phoneme of a word is the most parsimonious method. Hewlett (1990) speculates that the shift from a syllabic to a segmental focus is prompted by the need for intelligibility. Whilst listeners may cope with the idiosyncratic representations of the first 50 vocabulary items after this it becomes essential for intelligibility that the child's pronunciation patterns begin to resemble the adult target more closely. Whilst both these suggestions offer plausible reasons for the observed shift in focus neither goes any way to explaining how such a shift is actually 'kick started' and what concomitant abilities are necessary for the changes to take place.

In his support for the proposal that, initially, children's attention is focused on syllabic units larger that the segment, or phoneme, Boucher (1994) reviews evidence from studies not only of speech errors, and of the abilities of pre-readers (see also Fowler, 1991), but also of illiterates and concludes that there is considerable evidence against the cognitive 'naturalness' of phonemes. Studies involving illiterate subjects (see for example, Goswami and Bryant, 1990; Bertelson and de Gelder, 1991; Morais, 1991; and section 1.3.3.3.) have shown that such subjects often fail to develop phonemic segmentation skills. However, other authors (see, for example, Treiman and Breaux, 1982; Lundberg, 1991; Mann, 1991) have cited evidence that some subjects without literacy skills can, exceptionally, perform phonemic analysis.

In summary, whilst there appears to be evidence for a relationship between the transition from a holistic to a segmental focus and maturation, the direction of the relationship between literacy and phonological processing is still a matter of much debate. (For a comprehensive review see the volume edited by Brady and Shankweiler, 1991; and also sections 1.3.3.3., 2.4.4. & 3.5.3.)

3.2.8. Experimental studies of the link between perception and production

Some studies have looked at the relationship between production and perception of phonemes in individual children. Locke (1980b) found that, in his study of 131 phonologically disordered children (mean age 5;3, range 3;1 to 9;9) (but only seven children were aged over 7;0), 27-39% of the phonemes that were misarticulated were misperceived. The highest number of errors occurred on the f/0 contrast. However, Bird and Bishop (1992) argue that, in the light of evidence that normally developing children find this contrast hard to discriminate in the absence of visual cues, the findings are hard to interpret without control data.

Strange and Broen (1980) report that although the three year old children they studied who did not produce [w], [l] and/or [r] correctly could differentiate between [r] and [l], and [r] and [w] in a highly structured task and after considerable practice, their spontaneous performance indicated perceptual difficulties specifically related to those phoneme contrasts not yet differentiated in production.

Morgan (1984), studied 20 pre-school and 15 school age speech impaired children and a control group matched for age and sex. Intellectual level and socio-economic status were unfortunately not formally assessed. None of the subjects were judged to have problems of auditory acuity. The speech perception test involved the children indicating which of a pair of pictures had been named (e.g. pear/bear). Morgan (1984) found that both the pre-school and school age 'normally speaking' children made fewer errors on the auditory discrimination task than the speech impaired children with the difference being greater for the pre-school children.

Additionally, Morgan found that the same word pairs were found difficult across all groups; specifically fan/van, mouth/mouse, wing/ring, sum/sun, crown/clown, and train/chain. She suggests that these pairs may be 'inherently' difficult despite the improvements in speech perception occurring with age. However, Morgan (1984) did not find that the subjects were more liable to make errors of discrimination on the contrasts that they were unable to produce compared with those that they could. Bird and Bishop (1992) suggest that one reason for this finding might be the relatively small number of test items which did not allow such a trend to emerge; a factor which would have been linked with sample size. Morgan's (1984) subject groups were not large which would further compound these methodological difficulties.

In an interesting study of 14 phonologically impaired children (2 girls and 12 boys) ranging in age from 5;0-6;3 years (mean 5;7) Bird and Bishop (1992) chose to measure speech perception using both real word and non-word stimuli. The construction of both forms of the test was based on each child's phonological production with a control group being given the same items as their matched pair. The inclusion criteria included normal comprehension of language (as measured by a vocabulary test), no known physical causation, no hearing loss and monolingualism.

Bird and Bishop (1992) found that performance on the non-word discrimination task was unrelated to severity of phonological disorder whereas performance on the real word task was significantly related. In a similar finding to that of Howell (1989) (see 3.5.2.), Bird and Bishop (1992) reported that only some phonologically disordered children had poor auditory discrimination and, on this evidence, the authors could not support a theory which attributes all phonological disorders to underlying discrimination problems (the auditory hypothesis). Bishop and Bird suggest that a possible explanation might be that (see section

3.5.5.) the persisting phonological impairment was related to earlier difficulties in speech perception which had since resolved. A study of the inter-relationship between auditory discrimination and phonological processing in younger children might be one way of testing this hypothesis.

3.2.9. Laboratory based studies of the link between perception and production

Some recent studies of acoustic perception (see Gathercole and Baddeley (1990) for a review) have provided convincing evidence from laboratory studies that language disordered children have difficulties with the perceptual processing of acoustic stimuli. Deficits have been identified for synthetic acoustic stimuli containing rapid transitional information, and for speech stimuli in acoustically degraded environments. (For an interesting review of laboratory studies of auditory perception and reading skills, see Watson and Miller, 1993.) Such studies have also shown continua of results, for example that younger children's detection of formant transition differences were poorer than adults (Sussman, 1993) and that younger children with developing linguistic skills, children with specific language impairments and those with moderate intellectual impairments have poorer fine graded speech perception than normally developing children (as measured by a task which determined the smallest acoustic differences which could be detected among CV syllables) (Elliot and Hammer, 1993).

Similarly, some laboratory studies of auditory processing have focused on the ability to discriminate and categorise synthetically produced phonemes. As in the case of the non-laboratory studies the results have been somewhat inconsistent. Rvachew and Jamieson (1989) found that children most likely to have problems in discriminating synthetically produced voiceless fricatives were those whose production errors involved substitution of one fricative for another whereas Ohde and Sharf (1988) found no relationship between perception and production. In an investigation of the relationship between speech perception and speech production, Raaymakers and Crul (1988) studied monolingual Dutch speaking children, aged 6-7 years, who misarticulated the final consonant cluster (-s).

They compared their performance with three control groups, one including children who misarticulated other phonemes but not the target cluster, one including children who had no articulation difficulties and a group of normally articulating adults.

Raaymakers and Crul (1988) found that the poorer the articulatory proficiency (measured by the silence periods in the production of the Dutch word 'muts') the more variability there was in perception and production. In perception, the variability was not restricted to /-ts/ but included the whole /-s/ to /-ts/ contrast. Interestingly, the authors argue that children who did not have problems with either the perception or production of adult-like phonological targets, still did not exhibit perception or production equal to that of the adults. Their results were more variable suggesting to Raaymakers and Crul (1988) that whilst the internal representation was correct, it was not firmly established.

3.3. SPEECH PERCEPTION

3.3.1. Introduction

Many papers have been written about the way in which sound, and specifically speech sounds, are perceived (for example see the comprehensive collections of papers edited by Miller, Kent, and Atal, 1991; and Mattingly and Studdert-Kennedy, 1991). However the primary focus for this section, and chapter, is not the perceptual discrimination of speech sounds but phonemic perception (Barton, 1980); the ability to detect the minimal units which signify meaning differences. Some children who have normal auditory acuity may fail to discriminate phonologically significant acoustic features. (Stackhouse and Wells, 1993). Further, speech perception difficulties may fail to be detected due to the nature of the discrimination tasks (see, for example, sections 3.2.8. & 3.5.6.).

3.3.2. The development of speech perception

Evidence that auditory discrimination develops with age comes from a wide range of studies of speech perception skills in babies and children (see the comprehensive collection of papers edited by Miller, Kent, and Atal, 1991; Mattingly and Studdert-Kennedy, 1991).

Menyuk, Menn and Silber (1985) review the evidence about the development of perception and conclude that at one month the child is capable of discriminating between some of the acoustic parameters that distinguish speech sounds. By nine to thirteen months the child may be able to comprehend sequences of phonemes tied to particular contexts and by ten to twenty two months the child can learn to associate objects with nonsense words that contrast initial consonant features. By thirty five months the child can distinguish between minimal pair words which contain most English singleton phonological contrasts.

3.3.3. The measurement of speech perception

Speech perception has been measured in many different ways. Locke's comprehensive reviews (1980a, 1980b.) of more traditional methodology (see also section 4.8.1.) include discussion of same different judgement-, odd one out- and ABX tasks; all with the stimuli presented by the tester. Such procedures have been well used in the field but more recently the assessment of speech perception has also involved laboratory (often computer controlled) studies of, for example, the ability to detect small acoustic differences between stimuli (for a review see Elliot and Hammer, 1993).

It would seem vital, if their contribution is to be assessed, to evaluate speech perception skills in a way that is least likely to be affected by other phonological processing skills; that is, the tasks should not have a high phonological memory load, not require implicit segmentation skills and not require a verbal response. The first two constraints rule against tasks involving non-word stimuli and the second advocates a pointing response (see section 4.8.1.2.). The tasks should require identification of acoustic similarity/difference with no additional manipulation otherwise a phoneme segmentation task and a speech perception task may become identical (as indeed seems to have been the case in the study reported by Carlisle and Nomanbhoy, 1993).

Perceptual skills, carefully assessed should not only reflect auditory acuity but also provide a clue as to the nature of phonological awareness and the inter-relationship of metalinguistic skills with other phonological processing domains such as phonological memory and speech processing abilities. The next section extends the consideration of phonological processing to theories of speech production.

3.4 SPEECH PRODUCTION

3.4.1. Introduction

Menyuk, Menn and Silber (1986) specify the following speech production tasks which the child has to master during development.

- to learn to produce a variety of sounds
- to learn to produce vocal sound patterns so that they more or less match sounds which are heard (imitation)
- to learn to remember certain sound patterns well enough to produce them without just having heard them (delayed imitation)
- to learn to produce specific sound patterns in situations where they have been produced by others or oneself in the past (situation-bound word use)

Developing speech production skills can be profiled in two ways which reflect different aspects of speech development; speech sounds the child misproduces, and 'error' patterns in the child's speech. The first approach relies on transcribing the phonetic characteristics of speech sounds the child produces and has resulted in tests such as the Edinburgh Articulation Test (Anthony, Bogle, Ingram and McIsaac, 1971) which chart phonetic development up to 6;0 years of age.

3.4.2 Phonetic development

The phonetic complexity of individual sounds in terms of the gestures required to articulate them will determine ease of production (Stoel-Gammon and Dunn, 1986) Phonetic development continues during the first 12 years of life. A child may be at least 5;0 years old before he masters phonemes such as 'th' or the 'r/w' distinction (Fry, 1969).

Evidence for more subtle developmental changes comes from studies of duration, variability and coarticulation (Hardcastle, 1982; Hewlett, 1990). Subjects below 12 years of age) have demonstrated slower speech rates than adults and have displayed greater individual variation in segment and phrase durations. The neuromuscular mechanisms which control speech movements have been shown to be less mature in children than in adults accounting for some of the variation in speed. Coarticulation refers to the partial overlapping of speech sounds (Hewlett, 1990) caused by overlapping in the sequence of gestures that produces them. Coarticulation is an important factor in the efficiency of speech motor control since it allows continuity and fluency of movement. Hewlett (1990) reviews the evidence and concludes that while some studies argue a relationship between maturity and coarticulation others suggest that chronological age may be a less influential predictor of coarticulation than of speech rate and variability. Howell and McCartney (1990) summarise by suggesting that phonetic production is subject to motoric constraints and is influenced both by phonological contexts, environmental factors and cognitive influences.

3.4.3. Phonological development

The second approach to profiling child speech, whilst not totally independent of the first (see section 4.8.2. for additional discussion of speech processing assessments), differs in that it is based on an understanding that children who are learning to talk do not only need to learn how to articulate a range of phonemes. They also need to learn how to combine and contrast these sounds in a meaningful way. They have to know how to integrate features of voice, place, and manner to physically produce speech sounds and have to acquire the rules of their adult language which determine how the segments are organised to form words (Ingram, 1986; Howell and Dean, 1994). For the majority of children the mastery of the phonology of their language is nearing completion by 4;6 years of age.

3.4.4. Simplifying phonological processes

In what context is this mastery gained? Young children do not use adult pronunciation patterns . However, in children whose speech is developing normally it is possible to discern an underlying 'rule system'; that is to write a description of the relationship between the child's production and the adult target (Hewlett, 1990). For example, it is common for children younger than 3;0 years to 'stop' fricative sounds; producing the word "shoe" as "two". The reason that such descriptions can be termed 'rule systems' is that the pronunciation patterns tend to be systematic; that is, if a child, at a certain stage of development pronounces "shoe" as "two", it is likely that s/he will also pronounce "see" as "tea" and "show" as "tow". Such a child is said to exhibit the process 'Stopping of fricatives'. (See section 4.8.2.1. for a summary of simplifying phonological processes commonly seen in normally developing child speech.) Such rules may be context dependent; in the current example fricatives may not be replaced by stops in all syllable positions but only in syllable initial position. Further, the degree of variation will differ with different children.

> "The important implication of this is that the children's phonological patterns exhibit regularities which yield to a systematic description within a phonological framework."
> (Hewlett, 1990 p 19.)

3.4.5. Psycholinguistic models of speech processing

Models of speech processing can also add to our understanding of the development of speech production. Throughout this discussion Hewlett's (1990) model of phonological processing and phonetic production has been used as an exemplar. It is a particularly useful model in the context of this thesis as it attempts to account not only for the relationship between input, and output, lexical representations, but also for the relationship between phonological representations (albeit in a motoric form; see Section 3.2.4.) and phonetic implementation. Hewlett (1990) proposes syllable and segmental level motor processing components that are responsible for assembling the motor plan of the sequence of gestures involved in the word and determining the precise values of the articulatory parameters involved. The Motor Programmer receives an auditory-perceptual representation from the Input Lexicon which it uses to devise a motor plan which will be the basis for the mapping rules which 'translate' feature values from the auditory-perceptual plan into representation in the Output lexicon. That is, the Motor Programmer is provided by the Input Lexicon with the perceptual targets for spoken output. The Motor Processing component co-ordinates the motor plan of the sequence of gestures involved in actual production.

If a motor plan has been specified it can be entered into the Output Lexicon and accessed directly by the Motor Processor without reference to the Motor Programmer. That is, Hewlett proposes two alternative routes to the Motor Processing components; one the highly automatised route in which a word is selected directly from the Output Lexicon and implemented by a well practised set of motoric commands. The other route is through the Motor Progamming component which receives the auditory-perceptual representation of a word from the Input Lexicon and attempts to devise a motor plan for its production. This route might be conceptualised as operating when an unfamiliar word is to be produced. Once a motor plan is completed it can be passed to the Motor Processing component and, in future, be accessed through this automatised route.

Chiat and Hunt (1993) also adopted a model which divides phonological representation into two components (establishing or accessing lexical phonology and phonological encoding), and discuss the implications of different potential error patterns (on a non word repetition task) for such a model. Chiat and Hunt (1993) suggest that an impairment at the level of establishing or accessing lexical phonology would lead to

- variation between lexical items with some being more/less accessible than others
- fewer errors in repetition tasks(where lexical access is bypassed) than in naming or spontaneous output (where lexical information must be retrieved)

whereas if the problem lies at the level of phonological encoding the researcher might expect

- similar errors in repetition, naming and spontaneous speech
- errors to reflect phonological complexity
- errors to be sensitive to phonological but not lexical factors

Whichever components, or modules, are adopted in the modelling of speech processing it is

> "Children's ability to analyse the speech stream is the central issue in all of these areas" (Stackhouse, 1989. p 172).

3.4.6. The link between phonetic and phonological processing

The debate about the link between phonetic and phonological development has been fierce, as Keating's (1988) review illustrates. She discusses the view, taken by Dinnsen (1980), that articulatory constraints never motivate a particular rule. However, Keating (1988) concludes that phonological systems across languages have enough commonalties (from their basic constituent units to particular rules to warrant the conclusion that these systems are, at least indirectly, grounded in phonetic substance.

The dividing line between phonetics and phonology has become harder to draw since studies have begun to provide evidence that the phonetic parameters of phonological contrasts can be measured and that there is a learned cognitive element to phonetic, as well as to phonological, development (Hewlett, 1990). One example is the finding of Macken and Barton (1980) that whilst pronunciations of /t/ and /d/ may gradually become distinct to the listener (when the child is three to four years of age and the simplifying phonological process of 'voicing' is eliminated) instrumental studies of voice onset time (VOT) show that it is not until around eight years of age that VOT values become adult like.

A further link between phonetic and phonological processing has been postulated in the study of the origin of phonological processes. Papers by both Menyuk, Menn and Silber (1986) and Hewlett (1990) propose that there might be a relationship between immature phonetic skills and the development of simplifying phonological processes. That is, such processes may have become established to allow the child to compensate for the limitations of their neuromuscular processing.

The next section will consider published evidence about the relationship between phonological processing abilities and phonological awareness.

3.5. THE RELATIONSHIP BETWEEN PHONOLOGICAL PROCESSING AND PHONOLOGICAL AWARENESS.

3.5.1. Phonological awareness and speech perception: evidence from studies of normal development

What is known about the relationship between metaphonological abilities and phoneme perception? Many studies of phonological awareness (even those which have compared phonologically disordered children and controls) have not assessed speech perception explicitly (for example, Bryant and Bradley, 1983; Bowey and Patel, 1988; Bryant, Bradley, MacLean and Crossland, 1989; Chaney, 1989; Bryant, MacLean and Bradley, 1990; Felton and Brown, 1990; Magnusson and Naucler, 1993; Bowey and Francis, 1991; Warrick and Rubin, 1992) even when they excluded specifically children with hearing loss from the study (for example, Kahmi and Koenig, 1985).

However, there is some evidence that there may be a relationship between speech perception and phonological awareness. Yopp (1988) studied 50 boys and 54 girls with a mean age of 5;10 (range 5;4 to 6;8) from predominantly white, lower/middle class homes in southern California. They had received some instruction in sound/symbol correspondences and a limited sight vocabulary had been introduced. However, intellectual level or reading skills were not controlled for. Yopp used the Wepman auditory discrimination test (Wepman, 1973) (which involves the child in judging which pairs of words are the same and which different) and found the results had only low correlations with tests of phoneme awareness including blending, counting, deletion and segmentation. There was some evidence that perceptual skills were involved in one factor Yopp isolated, which she called Simple Phoneme Awareness.

Chaney (1992) studied 43 children with a mean age of 3;8 (range 2;9 - 4;2) who were monolinguistic but who came from a variety of social backgrounds. All subjects were tested for normal auditory acuity, and for overall language development (the latter being estimated by a vocabulary test). Auditory discrimination was tested by a task which required the child to select one from three where two items were identical apart from the initial sound and one was a foil (i.e. goat, boat, ball). Unfortunately the results were difficult to interpret as the scores for the auditory discrimination test were combined with those of the articulation test for the purposes of the analysis. Whilst Chaney (1992) provides no rationale for this combination it is tempting to suppose that it represented a tacit recognition that both skills were in some way related to the 'gestalt' of speech processing. However, as Chaney's (1992) discussion is presented, such an assumption is not justifiable. Together, the auditory discrimination and articulation scores were not correlated with other linguistic measures such as vocabulary or sentence structure, and appeared to be relatively independent skills. Further, the composite score did not correlate significantly with the measures of phonological awareness which included measures of phoneme judgement, and synthesis, and rhyme production and identification.

3.5.2. Phonological awareness and speech perception: evidence from studies of phonological disorder

Howell (1989) investigated the phonological awareness of 21 phonologically disordered children (mean age 4;2, range 3;8-5;5) and 21 normally developing children (mean age 4;3, range 3;10-4;9) She found a correlation between auditory discrimination and phoneme segmentation for the total population, and for the phonologically disordered group.

However, this correlation did not hold for the normally developing subjects. Howell (1989) found that whilst the best discriminators in the disordered group were also among the best segmenters, the relationship did not always hold good. Some children in both groups were poor at phoneme segmentation. However, Howell's (1989) study did not include a regression analysis so that variation due to variables such as intellectual level, family background and general language processing skills could not be estimated.

Bird and Bishop (1992) also carried out a series of metaphonological tasks (including phoneme matching, rhyme judgement and rhyme generation) with their subjects (see section 3.2.8. for a fuller discussion of this study) and found that the phonologically impaired children had clear difficulty with these tests particularly with rhyme generation. The authors argue that the phonologically impaired children had problems with phonological awareness as well as discrimination suggesting that the underlying problem is neither motor (the motor hypothesis,) or sensory (the auditory hypothesis), but is one of learning how to categorise speech input. Bird and Bishop (1992) propose that the problem for the child lies not only in discovering criteria for phoneme categorisation but also in recognising that words can be analysed at the level of phonemic segments. Bird and Bishop (1992) conclude, first, that adequate auditory discrimination does not necessarily mean that the child's processing of phonological input is normal. They suggest that, for many children, the ability to recognise some sounds across different contexts may be problematic. Second, Bishop and Bird (1992) argue that these findings suggest that young and phonologically disordered children may attend to the composite word patterns in preference to individual components (see sections 1.3. & 3.2.7. for a fuller discussion of debate about the basic units of phonological processing).

3.5.3. Phonological awareness and speech perception: evidence from studies of reading disorder

Studies of poor readers have also indicated a link between phonological and speech perception skills. In a study of auditory perception, phonological processing and reading skills in 94 college undergraduates, 24 of whom were diagnosed a having reading difficulties, Watson and Miller (1993) found that speech perception skills (as measured by speech repetition, syllable sequence discrimination and degraded speech tasks) were strongly related to both phoneme segmentation and to short-, and long-, term auditory memory skills.

Brady, Shankweiler and Mann (1983) found that 8 year old poor readers made significantly more errors than good readers when repeating single syllable words presented with noise masking, although they performed as well when the test items were non-linguistic sounds or when the noise was reduced. These findings suggest that the problems of poor readers are focused on the linguistic domain (Mann and Ditunno, 1990) but do not allow a conclusion that the problem with speech perception is current at the time of testing or that its effect is direct. Snowling, Goulandris, Bowlby and Howell (1986) suggest that early limitations on perceptual analysis may have prevented the establishment of phonological representations for words and that the incomplete representations will, in turn, hinder performance on a repetition tasks. Alternatively, repetition may also be affected if output phonology cannot be directly accessed (see sections 3.4.5.). This argument, coupled with the suggestion that repetition of nonwords/unfamiliar words requires implicit segmentation skills could mean that poor phonological awareness is interfering with reading disabled subjects' performance on speech repetition tasks rather than that poor speech perception is affecting repetition skills.

However, based on the findings of an interesting study Brady (1991) argues against the conclusions drawn by Snowling et al (1986). Brady found that to detect speech perception deficits in poor readers the tasks had to be somewhat more demanding. The poor readers failed to detect monosyllabic words in noise but had no difficulty with the same words without noise. Brady argues that in non-word repetition tasks it is difficult to be certain whether the difficulties arise during the perception or production component of the task or are due to the common requirement of formulating a phonological representation.

3.5.4. Phonological awareness and speech perception: accounting for the inconsistencies

How can the inconsistencies in the findings of these studies of speech perception and its correlates be accounted for? There are several possible explanations. In Chiat and Hunt's (1993) study of lexical processing in a language impaired 6 year old child, they argue that current performance on tests of auditory discrimination cannot rule out the possibility of problems at an earlier developmental stage which could have affected the establishment of lexical representations and have contributed to observed speech processing difficulties. A similar explanation is postulated by Bird and Bishop (1992) in the context of phonological impairment and by Snowling, Goulandris, Bowlby and Howell (1986) for a link between reading difficulties and developmental auditory perceptual skills (see section 3.5.3. for a fuller discussion). So, one explanation for contradictory findings might be that the interaction between input and output phonological processing had occurred before some studies measured auditory discrimination skills.

An alternative suggestion is that a test of auditory discrimination requiring same/different judgements might be too non-specific. It might not demonstrate difficulties that would be profiled by tests of, for example, sound sequence discrimination using non word stimuli (see Stackhouse, 1993). Real word stimuli allow the possibility that lexical skills can be used to aid perceptual skills in completing the task. Thus semantic processing 'strengths' may mask limitations in speech processing skills. It is even arguable that auditory perceptual deficits might only be demonstrated with a laboratory context.

Further clues to the reason for such discrepancy might lie in the growing recognition that children diagnosed as having disorders of the speech sound system may not be a homogeneous group (see Grunwell, 1981; Bird and Bishop, 1992; Dean, Howell, Waters and Reid, 1995) with the possibility of processing being disrupted at the levels of, for example, the phonological output lexicon (phonological disorders), motor planning (dyspraxia) or motor execution (articulation problems). Few papers have been explicit about the process by which children's pronunciation difficulties were assessed or about the nature of concomitant language processing difficulties. In contrast, papers such as that of Chiat and Hunt (1993), Stackhouse (1993) and Stackhouse and Wells (1993) provide excellent examples of thorough diagnostic analysis.

3.5.5. Phonological awareness and speech production: evidence from studies of phonological disorder

Howell (1989) carried out a study of phonologically disordered children's ability to make acceptability judgements and corrections . She reduced the memory load within the task by presenting the children with (pre-recorded) single words rather than sentences and by accompanying the auditory presentation with pictures of the items concerned. Some of the items were correctly pronounced an others contained phonological errors (for example, 'shoe' was pronounced as /ku/).

The subjects were 21 phonologically disordered children (pdg) as defined by standard scores below 85 on the Edinburgh Articulation Test (Anthony, Bogle, Ingram and McIsaac, 1971). These children had a mean age of 4;2 (range 3;8 to 5;5) and were compared with a group of 21 subjects with normally developing speech (ndg) who had a mean age of 4;3 (range 3;10 to 4;9). There was no significant difference between the two groups on formal tests of non-verbal intelligence, auditory discrimination or auditory sequencing. However, the phonologically disordered group had significantly ($p>.05$) lower scores on a standardised test of comprehension of language (Reynell, 1977). Howell found that the majority of subjects in both the phonologically disordered and normally developing groups judged the pronounced words appropriately but it appeared that, when a child did judge a word to be wrong, the judgement was made on semantic grounds. The children were less willing to provide corrections (at the prompt "What should he have said?") and the phonologically disordered children were less likely to produce the adult target as the correction.

Further, Howell (1989) compared the phonologically disordered group (pdg) and the normally developing group's (ndg) performance on metaphonological tests, including rhyming and segmentation tasks. Howell found that the phonologically disordered group had poorer rhyming, segmentation, and non word repetition skills. However, there was individual variation which resulted in some of the phonologically disordered performing within the range of the normally developing subjects.

Magnusson (1991) argues that, whilst levels of linguistic awareness vary in normally developing children, the range is considerably greater in language disordered children. The language disordered group may have varying levels of metaphonological skills for all the same reasons as the normal population. However, she suggests that there may also be specific difficulties underlying the poor levels of awareness that some language disordered children display (see section 2.3.3. for a discussion of these specific difficulties).

In her thesis Howell (1989) suggests that the most profitable explanation for her findings might be in terms of an auditory processing deficit. She argues that poor auditory processing skills may underlie both poor phonological awareness and poor phonological development. Stackhouse (1990) made a similar link in her information processing model of the relationship between primary and secondary language skills, and awareness of language units. She argues that speech, reading and writing problems can be different manifestations of the same phonological processing problem. Stackhouse argues that

> 'Children's inability to discriminate similar sounding words and to segment the acoustic stream will affect their lexical development and their ability to assemble motor programs of their articulation.' (p178)

However it is unclear whether, in this model, Stackhouse is proposing that a basic auditory processing deficit or a deficit in segmentation skills are precursors to both metalinguistic development and primary and secondary language acquisition, or whether linguistic awareness itself is the precursor.

3.5.6. Phonological awareness and speech production: Accounting for the inconsistencies

Further pointers to the way ahead for future investigation are provided by Magnusson (1991) in an interesting review of the literature on, and her own longitudinal studies (together with Naucler) of, the linguistic awareness of phonologically disordered children. Magnusson (1991), like Howell (1989), rejects the simplistic view that a child who exhibits output restrictions affecting pronunciation will necessarily have poor phonological awareness and thus have difficulty with, for example, phoneme segmentation tasks.

Magnusson argues that some of the discrepancies apparent in the research findings can be attributed to task differences with some metaphonological assessments making higher task demands. For example, Magnusson (1991) suggests that the risk that a rhyme awareness task might be failed because of the disordered child's limited lexicon is lessened if a rhyme detection task is used rather than a rhyme generation task. Similarly she suggests that the cognitive load in such an assessment can be manipulated to try to ensure that the task is not failed by a child who can demonstrate rhyming ability. A study by Vance, Stackhouse and Wells (1994) supports this proposal. These researchers found that the differing demands imposed by different forms of assessment of rime awareness led to differing outcomes. (See section 4.7.4.1. for a fuller discussion of this study.)

Considering the question of the influence of individual variation on levels of linguistic awareness, Magnusson (1991) argues that her analysis of the literature supports Howell's (1989) conclusion that whilst many phonologically disordered children perform on tasks of phonological awareness at a lower level than age matched controls, some phonologically disordered children do fall within the normal range. Magnusson (1991) suggests that there are at least three different possibilities as to the reason that language impaired children perform less well on metalinguistic tasks than do normally developing children. Magnusson argues that these are; first, that a child may not have developed the cognitive skills necessary to reflect on, analyse, judge, or manipulate language and its structural characteristics. Second, Magnusson argues that a child may be able to access linguistic knowledge but that that knowledge may be deviant or incomplete and third, that the language disordered child may have access to normal phonological representations even if their speech output is deviant.

3.6. SUMMARY

This chapter has considered the interrelationship between speech processing and phonological awareness from different perspectives. The nature of speech perception and production has been explored; the interaction between speech perception, central processing and speech production highlighted; and the interrelationship between speech processing and phonological awareness discussed.

The review of the studies summarised in this chapter suggests that there is sufficient evidence of a link between these distinct abilities to warrant further investigation. Specifically, there is evidence that careful measurement of processing abilities in the areas of speech perception and production would allow an evaluation of the contribution of phonological processing to the development and functioning of phonological awareness.

However, some of the studies reported in Chapters 1-3 have methodological features which have prevented conclusions being drawn from the evidence they provide. These features include a lack of control for factors such as cognitive processing, age and social class; poor specification of the nature of the language processing difficulties; a failure to assess comparable levels of linguistic and metalinguistic processing; and an over reliance on cross-sectional studies.

The argument of this thesis is that a focus on comparable levels of metalinguistic and linguistic functioning (specifically metaphonology and phonological processing) together with controls for influential variables such as age, nonverbal cognition, general linguistic skills, memory and literacy skills, will allow a more accurate evaluation of the nature and correlates of phonological awareness than has been possible in previous studies.

The review undertaken in Chapters 1-3 highlights methodological issues which need to be taken into account in the design of a study of the nature and correlates of phonological awareness. The current investigation was designed to avoid the methodological pitfalls identified. The experimental design is a longitudinal study of 46 children, aged four years, who are assessed, and then reassessed one year later. Age is held constant, with all children being tested within one month of their birthday. The assessment battery includes measures of variables that the review of the literature, reported in Chapters 1, 2, and 3, indicates will be influential. The current study includes a comprehensive measure of phonological awareness designed to be capable of profiling metaphonological abilities of both four, and five, year old children. There are also measures of auditory memory, speech perception and production abilities, vocabulary skills and nonverbal intelligence. Chapter 4 details the rationale for the inclusion of individual measures within the test battery, describes the tests specifically constructed for this study, and presents the outcomes of the pilot study.

CHAPTER 4
The pilot study

4.1. INTRODUCTION

This chapter will provide a description of the pilot study methodology followed by a discussion of the underlying rationale for the choice of assessments; first, the assessments specially constructed, or adapted, for the study and second, the formal, standardised assessments employed. There will also be discussion of the way in which the specially constructed assessments were adapted, or further adapted, as a result of the pilot study.

4.2. AIMS

1. To devise a set of subtests that will tap phonological awareness in children aged between 3;11 and 5;0 years old and which can be administered in a school or clinic setting.
2. To develop standardisation of test administration and scoring.

4.3. PURPOSE

The pilot study was essential for the researcher to

- evaluate the test of phonological awareness
- evaluate the non standardised assessment of auditory discrimination (adapted from Howell, 1989)
- practise administration and scoring skills related to the standardised assessments
- gauge the feasibility of administering the whole assessment battery to children in a school or clinic setting.

4.4. SUBJECTS

The children involved in the pilot study were drawn from one Lothian Health Board nursery class attached to a local primary school, one independent nursery school, and from children who had previously been involved as babies in the Child Studies carried out by first year undergraduate speech and language therapy students at Queen Margaret College. The children met all the criteria laid down for the main study (see section 5.4.2.) and came from a range of family backgrounds.

4.5. ETHICAL APPROVAL

Ethical approval for the study was obtained from the Ethics committees of both Queen Margaret College and Lothian Education Department.

4.6. METHODOLOGY

The relevant parents were contacted by means of a letter (see Appendix 1) in which the research was explained and their child's involvement detailed. A consent form (see Appendix 1) was provided and all parents contacted returned these. The children were each seen for three to four assessment sessions each lasting 35 to 40 minutes. All testing took place in a quiet room with only the tester and child present. Following testing the parents, children, head teachers and teachers were all thanked by letter.

4.7. THE TEST OF PHONOLOGICAL AWARENESS (PA)

4.7.1. Introduction

This test was constructed especially for the study. It was designed with the following criteria in mind; i.e. that the test should

- include a range of subtests that the literature suggested would tap phonological awareness
- provide an overview of a child's ability by tapping several levels of phonological awareness (see section 1.3.)
- encompass a range of difficulty to reduce the chances of 'ceiling' or 'floor' effects
- tap the detection/correction/explanation continuum (see section 2.2.3.)
- be constructed so that each subtest involved an appreciably different response/involvement from the subject to sustain interest

- be constructed with attention to the memory requirements of each subtest, in terms of the cognitive load imposed by the task (see sections 3.5.6.).

Four subtests comprised the test of phonological awareness: acceptability judgement (pa1); phoneme identification (pa2); rime judgement (pa3); and feature analysis (pa4) tasks. See Appendix 2 for the items and scores sheets for each of these subtests. Table 4.1. (section 4.7.6.) for a summary of the main features of each subtest following piloting.

The subtests of the assessment of phonological awareness were initially piloted on a wide range of children. When revised they were administered in their final form, along with the remainder of the assessment battery, to a group of 13 subjects (8 girls and 5 boys).

4.7.2. Acceptability Judgement Subtest (Pa1)

4.7.2.1. Introduction

This subtest assesses the child's ability to detect, correct and explain phonological errors. Howell (1989) carried out a study of three and four year old phonologically disordered and normally developing children's ability to make acceptability judgements, corrections and to give explanations for these choices. She reduced the memory load of the tasks by presenting the child with (pre-recorded) single words rather than sentences (as used by Kahmi and Koenig, 1985) and by accompanying the auditory presentation with pictures of the items concerned. Some of the items were correctly pronounced and others contained phonological errors (for example, 'shoe' was pronounced as 'tu'). The children were asked to judge the words, correct them and give reasons for their answers.

Howell found this format satisfactory (see section 3.5.5. for a full discussion of her findings.) However, so few children were able to attempt explanation that this part of the task was not included in Howell's main study. The majority of children were able to recognise error, but were rather less willing to provide corrections. The phonologically disordered group, as might be expected, were less successful at producing the adult target in the correction task.

4.7.2.2. Construction and piloting of Acceptability Judgement subtest

The current study adapted Howell's design slightly by altering the order in which the judgement, correction and explanation tasks were presented.. Following the introduction:-

> "I've got a friend who is learning to talk. Have you got a baby at home who is learning to talk? My friend makes some silly mistakes when she's telling me names. Listen to this and see if she says a good word or a silly word."

The children were asked first "Was that a good one or a silly one?", (if the answer was 'silly') second, "How did you know it was a silly one?" and third "What should she have said?"

The pre-recorded items were accompanied by pictures of the target to lessen memory loading. This format worked well, resulting in many judgements, and some corrections and explanations. However, the explanations could not be scored as the children often produced one or two useful examples and then, perhaps due to the nature of the prompting, appeared to assume that the 'correct' answer to the second question must have been a correction. However, the request for explanation was still included as it could be analysed qualitatively.

The original format included thirty items; ten correct, ten with phonological errors which relate to those processes noted to occur during speech development (see Chapter 2), and ten items with phonological errors not likely to occur within the normal developmental process. It was hypothesised that the latter type of errors would be more likely to be identified than errors which occur developmentally. The items were presented in a random order which was the same for each child.

Analysis of the results suggested that the ten non developmental error items were redundant in that all children detected these. The subtest also proved rather lengthy and the children became demotivated. The number of items in the subtest were therefore reduced by including only the correctly produced items and the items which had errors which occur developmentally. Finally, one of the pictures was changed as the majority of the children failed to recognise the salient feature ('gate'). (See Appendix 2 for test items and score sheet.)

4.7.3. Phoneme Identification subtest (pa2)

4.7.3.1. Introduction

As discussed in section 1.3.2. some earlier studies of phonological awareness failed to distinguish between onset, rime and phoneme awareness with the result that the findings are, at worse, contradictory and, at best, difficult to interpret. More recent studies have utilised the notion of onset and rime when choosing test items and (see sections 1.3.2.2 to 1.3.2.4.) The results have started to show that onset identification is possible at an earlier age than initial phoneme identification (where the initial phoneme forms only part of the onset). However, as with the rime judgement subtest (see section 4.7.4.1.), an important constraint on performance might come from output constraints. It is conceivable that responses on phoneme segmentation tasks which require the child to produce the initial phoneme (for example, Howell, 1989; Goswami and Mead, 1992), or to provide purposive mispronunciations, might be influenced by such constraints.

There are several segmentation task designs that avoid requiring a verbal response. For example, Bowey and Francis (1991; see section 2.3.4.2. for a fuller discussion of this study) employed an oddity task whilst Chaney (1992) investigated the ability to synthesise phonemes by asking the child to point to one picture (out of three) when the name was spoken by the examiner in a 'segmented fashion' (e.g. h-a-t). (For further discussion of this study see section 2.3.4.5.)

The current study adapted an experimental design used by Reid (1989). This format was adopted as it was felt that it would sustain the interest of the young children who formed the proposed subject group. Reid began the test by discussing with the children the notion that objects (represented by cut-up pictures) were composed of 'little bits'. Once the shared vocabulary was established, the experimenter moved the focus of the discussion to the child's name, the experimenter's name and either the name of a family member or of a puppet. The child was then asked to produce 'little bits' of their name. Finally, the child was then introduced to a puppet and asked to help the puppet with her homework 'finding little bits of words'. "First we tell her the word, then she will tell you a little bit of it. Will you tell her if she's right?".

4.7.3.2. Construction and piloting of Phoneme Identification subtest

For the pilot study Reid's procedure was only adapted minimally. The instructions given to the child were:-

> "I want to tell you about little bits of things. Everything is made up of little bits. This leg is a little bit of the table, The back is a little bit of the chair. You're made up of little bits too. Your nose is a little bit of your face, and your finger is a little bit of your hand. Your name is made up of little bits too. Listen ... (child's name). That starts with a /-/ sound . Can you hear it /-/ ... (child's name)? My name is Liz. Listen .... Liz. That starts with a /l/ sound...Liz. There's a sound at the end of my name too...Liz. Can you hear a /z/ at the end of Liz? What sound can we hear at the end of your name? (Child's name) I can hear a /-/ at the end of (child's name). Can you hear /-/? Look at this picture and listen. Its a sock. Sock. Can you hear a /s/ in 'sock'?"

The target items were all represented by pictures. The children were required to answer yes or no. Whilst these instructions appeared to be understood by the children in the pilot study, the majority seemed unable, during the instructions, to segment the individual sounds within their, and the experimenters', names . The majority of the children also went on to perform poorly on the subtest, as would have been expected both from the literature (see section 1.3.3.) and from their performance during the instruction phase. However, some of these children, when the sounds in their name were mentioned, spontaneously volunteered the information that they knew what sound their name started with. In all instances the children were correct. In the light of this observation, the instructions were therefore changed to capitalise on this awareness. The instructions were altered:-

> "Do you know what sound your name starts with? (Child replies)[1] That's right. (Child's name) starts with /-/ doesn't it. When I say (child's name), you can hear a /-/ sound can't you? My name's Liz. What sound does Liz start with ? It starts with /l/ doesn't it. When I say Liz, you can hear a /l/ sound at the beginning. There's a sound at the end of my name too...Liz. Can you hear a /z/ at the end of Liz? Listen....Liz. What sound can we hear at the end of your name? (Child's name) I can hear a /-/ at the end of (child's name), can you hear /-/? Listen........(child's name). Look at this picture and listen.[2] Its a sock. Sock. Can you hear /s/ in 'sock'? etc."

When piloted these instructions seemed to be more accessible to the subjects resulting in more conversation and spontaneous comment. In addition, the subtest administration was amended. Having completed the subtest, children who had shown the ability to segment the initial phoneme of their own name were asked if they knew what sound each of the stimulus pictures started with. This gave additional information about the early segmentation skills of subjects who had difficulty with the task posed by the subtest.

This subtest assessed children's' ability to recognise individual phonemes in word initial and word final position. Thirty items were included in the final version, all with CVC structure; 15 in which the stimulus phoneme did occur (targets). For 8 of these the stimulus item was in syllable initial position (i.e. sock) and for 7 in syllable final position (i.e. boat). There were also 15 distracters in which the stimulus item did not occur (i.e. Is there a /f/ in 'meat'?).

Of the 8 stimulus items in syllable initial position, 4 were stops (one example each of /p/, /d/, /k/, /g/) and 4 were fricatives (/s/, /f/, /v/, / /). These included voiced and voiceless exemplars. Of the 7 stimulus items occurring in syllable final position, 4 were stops (/p/, /t/, /k/, /g/) and 3 were fricatives (/s/, /θ/, /z/). The choice of the stimulus items and targets was dictated by a combination of the need to include a range of phonemes, and to have highly

[1] No children in the pilot study were unable to give the first sound of their name. If this occurred during the experiment the comment "That's right. " would be replaced by "Your name is (child's name) isn't it ? Listen (child's name). "

[2] This change was made to accommodate the comment, made by several children, that the puppet didn't say the word "You did!".

imageable items which were within the vocabulary of 4 year old children. (See Appendix 2 for test items and score sheet, and Table 4.1 for a summary of task format.)

As predicted from the literature, very few of the pilot children (within the age range 3;11 to 4;0) had any degree of success on this task. However, the subtest was included both because it allowed for a range of ability to be profiled by the overall assessment and because the metaphonological assessment was to be used in the second stage of the research (Experiment 2) with children aged 4;11 to 5;0.

4.7.4. Rime Judgement subtest (pa3)

4.7.4.1. Introduction

To be aware of rime and to invent rhymes children have, to some extent, to be aware that it is possible to segment words and syllables into smaller units (see section 1.3.2.). Although the onset has to be segmented from the vowel, and part of the syllable removed, a complete phonemic segmentation of the syllable is not necessary. To judge rime the child also has to categorise words as identical or not.

There is evidence that children perform differently on tests of rime production and detection, and that different types of task make different demands. Reid, Grieve, Dean, Donaldson, and Howell (1993) found that children who performed poorly on a rime detection task may still demonstrate the ability to produce rhymes. This phenomenon has been studied by Vance, Stackhouse and Wells (forthcoming) within the context of a longitudinal study. They investigated the differential task demands of visual and auditory stimuli, and of tests of rime knowledge, production, judgement and detection.

Vance et al hypothesised that if stimuli are presented only in a visual form the subject will have to access the relevant internal representation and, therefore, that performance will depend as much on the intactness of that representation as on the ability to make rime judgements. However, if the stimuli in detection tasks are presented auditorily, the child only has to detect similarities and differences. Vance et al (forthcoming) studied five groups of twenty children aged three, four, five, six, and seven; investigating their input, representational and output skills. Eight rhyme tasks were presented to measure rhyme knowledge; rhyme string production; rhyme judgement; and rhyme detection. Both the latter tasks had visual, auditory and non word forms. Results from all the tasks showed age effects. The judgement task was generally easier than the detection task, which also showed a modality effect (verbal presentation leading to reduced success rate) not evident on the judgement task. There were no significant differences between real and non word conditions, and Vance et al (forthcoming) argued that this indicates that the normally developing child performs these tasks without accessing lexical representations. Vance et al conclude that the fact that rhyme production was the 'easiest' skill tested, suggesting that it is a more automatic skill than judgement or detection which may require a more conscious level of phonological awareness.

Whilst the majority of studies focusing on rime have employed experimental tasks, some have chosen observational methodology in which no attempt is made to stimulate the production of rhyme. Such studies run the risk of drawing the false conclusion that, because children do not produce rhymes within a given time span, they cannot. Dowker (1989) chose a methodology which was a combination of an observational and an experimental study arguing that this design would reduce the likelihood of researchers falsely concluding that children who do not perform (in one particular situation) are unable to judge or generate rhyme.

The primary aim of the current study was not to investigate at what age children could recognise or manipulate rime but to compare a group of children on a set of variables, and thus the experimental situation was deemed most appropriate. Specifically, the current study aimed to compare children's phonological processing skills with their phonological awareness. If a child has output constraints affecting phonological aspects of their language, performance on a task requiring production of rhyme could be affected by these output limitations. A more accurate estimation of the ability to be aware of rime is to be gained by a rime detection task on which children's responses are less likely to be influenced by their pronunciation skills. Studies of rhyme production (i.e. Stackhouse and Snowling, 1983; Stackhouse, 1985) have shown that phonologically disordered children, asked to produce spontaneous rhymes, demonstrate their understanding of the task by producing one or two rhyming words but then, typically, go on to produce semantically related, or unrelated, words. This finding, together with the conclusions of Vance, Stackhouse and Well's (forthcoming) comparison of task formats, led the current author to choose a rime detection task.

One way to assess rime detection is through a task where the child is asked to judge which two items sound the same and to indicate the 'odd one out' (i.e. Magnusson, 1991; Kirtley, Bryant, MacLean and Bradley, 1989; Howell, 1989). One of the problems with this task format is the memory load it imposes, although this can be reduced by adding a picture for each item. Alternatively, the memory load of the task can be reduced by keeping the target rime constant and this was the design selected for the current study.

The task chosen was an adaptation of a test developed by Read (1978) and employed profitably by, for example, Smith and Tager-Flusberg (1982) and Chaney (1992). In Read's original task a hand puppet called Ed was introduced to the child, some training took place and the child was asked (for example) "Would Ed like *bed* or *car*?". The attraction of this task design was the enjoyment exhibited by the child. This subtest caught and held attention. Read (1978) had developed this format because he found that minor changes in task presentation brought a dramatic increase in successful completion rates. Read (1978) argued that the methodological changes that were important included embedding the experimental tasks in a context that made sense to the child, and giving the child a constant target ('Ed') for their judgements.

The influence of the relevance of the task on the child's performance was underlined by the experience of piloting of this subtest within the current study (see 4.7.4.2.). Following piloting, the instructions were altered to capitalise on the child's naturally occurring interest in rhyme at this age level, and on the pleasure children receive from rhyming jokes (Howell and Dean, 1994; Van Kleek and Schuelle, 1987).

4.7.4.2. Construction and piloting of Rime Judgement subtest

The children were shown a glove puppet named `Ed'. The experimenter then said

> "This is my friend Ed. He likes words that sound like him. Ed likes words like 'led' because 'led' sounds like 'Ed' . He also likes 'said' because 'said' sounds like 'Ed' too, doesn't it? But he doesn't like 'cap'. 'Cap' doesn't sound like 'Ed' does it? Now you have a go. Does Ed like (first test item)?"

A yes/no response was required. The children in the pilot study found this task difficult even when they obviously enjoyed the explanation and spontaneously demonstrated the ability to rhyme (for example, spontaneously saying "Ed bed!"). The children's responses during the subtest suggested that they had no real understanding of the object of the task .The literature (see section 1.3.2.) indicated that children as young as those in the current subject group could spontaneously generate rhyme, and found rhyme amusing. The instructions for this subtest were therefore changed in an attempt to capitalise on children's naturally occurring interest in rhyme. The revised instructions were :-

> This is Ed. He likes to make jokes. If he met you he'd say "Hello (child's name plus rhyming nonsense word i.e. `Sam bam')!". That makes him laugh. Its funny isn't it? And if he met me he'd say "Hello Lizzy pizzy!" If you met him you'd have to say something funny too. You could say "Hello Ed said!" That would make him laugh. Or you could say "Hello Ed led!" That's funny! But if you said "Hello Ed cap" that wouldn't make him laugh would it? They aren't funny. They don't sound the same. They don't rhyme! Would Ed laugh if you said "Hello Ed (first test item). Does 'Ed' (first test item) rhyme?"

In addition these instructions explicitly mentioned the word 'rhyme' as several children obviously understood this term, and made comments such as "'Ed' and 'bed' rhyme don't they?". The revised instructions were then tried with the children on whom the subtest had originally been piloted. Allowing for any familiarity or learning effects, the results seemed more promising and the revised instructions were then given to a second group of children. Whilst subjects demonstrated varying ability, the revised instructions appeared to contribute to the children retaining the purpose of the subtest, and to maintaining motivation.

The items selected for the final version of this subtest (see Table 4.1) included ten words and ten non-words, 5 of each rhyming with Ed. The non-words were generated by changing one phoneme from each of the rhyming and non-rhyming words. (i.e. head-med, fat-wat) to ensure a comparable phonotactic structure. All items had a CVC structure and were not pre-recorded but were spoken by the examiner. (See Appendix 2 for test items and score sheet.)

4.7.5. Feature Analysis subtest (pa4)

4.7.5.1. Introduction

This subtest is unique to the current study. It appears not to have been employed in any other studies of phonological awareness. It has its origins in the work by the author and her colleagues (see Dean and Howell, 1986; Dean, Howell, Hill and Waters, 1990; Howell and Dean, 1994; Dean, Howell, Waters, and Reid, 1995) which has centred on the development of strategies for the remediation of phonologically disordered children.

A central tenet of this approach is the need to build a child's awareness of speech sounds (their own and the target system) in order to facilitate change in the processing underlying their pronunciation disorder. The approach, termed Metaphon therapy, necessarily involves drawing the attention of pre-school children to the sound system of their language. Detailed single case studies of this work (Howell and Dean, 1994; Howell, Hill, Dean and Waters, 1993: Dean, Howell, Waters and Reid, 1995) have shown that children below the age of 4;0 years can participate in activities which focus on awareness of phonological contrasts.

The review of the literature in Chapter 2 suggests that in order to construct an assessment of phonological awareness in which children as young as 4;0 years can participate, it is necessary to include subtests measuring the ability to make acceptability judgements and to be aware of rime. These are currently the most promising experimental measures of phonological awareness for such young children. However, there is also an awareness that children demonstrate a holistic awareness before a segmental focus (see section 1.2.1.)

In order to broaden the assessment designed for this study the decision was made to pilot a measure of awareness of phonological features. The only published study found which had a test of any similarity was one of the earliest papers. Smith and Tager-Flusberg (1982) asked children to judge what a speech sound was; to differentiate between speech sounds ('ne', 'ba', 'o', 'lu', and 'a') and non-speech sounds (pop, click, hum, whistle and blow).

4.7.5.2. Construction and piloting of Feature Analysis subtest

This subtest was designed to assess children's ability to discriminate between phonemes on the basis of one distinguishing feature, voicing. The children were given a picture of two faces and the following explanation:-

> "These are two people who live in my street. This one is called Mr Noisy because he shouts a lot. Can you see his big mouth shouting? This one is called Mr Whisper because he likes to whisper all the time. Mr Noisy likes noisy sounds like /z/ and /v/ and /dz/. Mr Whisper likes quiet `whispery' sounds like /s/ and / / and /f/. I want you to listen to some sounds and tell me if Mr Noisy or Mr Whisper would like them."

This introduction was followed by a brief training period which involved the subject listening to a tape of the experimenter producing 5 fricative + vowel combinations. Before each presentation the experimenter said "I think its one of Mr. Noisy/ Whisper 's (as appropriate) sounds next". There was no further discussion. The subtest itself required the children to respond to productions of voiced and voiceless stops + vowels (all non words); four repetitions of /b/ and /t/, and three of /p/, /d/, /k/, /g/.

The phonemes (produced by the experimenter) were presented on a tape to ensure standard production. In the original recording the target phonemes were each followed by the open back vowel /a/. During piloting it became apparent that children's ability to judge the phoneme was masked by the acoustic quality of the vowel. The children judged the majority of the phonemes as voiced. This was contrary to clinical findings (see section 4.7.5.1.) which suggest that both very young children, and linguistically disordered children are aware of the voicing contrast.

The tape was re-recorded with each phoneme being following by a minimal schwa vowel to reduce as far as possible the influence of the following segment. The re-recording was then piloted and a greater spread of response obtained. This format was then employed for the main study. (See Appendix 2 for a copy of the score sheet and all items.) the final version comprised 20 items all of which had a CV structure with the consonant being a voiced/voiceless stop (see Table 4.1.)

4.7.6. Summary

Table 4.1. summarises the main feature of the individual subtests of the Test of phonological awareness.

Table 4.1. A summary of the main features of the subtests of the Test of Phonological Awareness.

Subtest	No of items	Form of items	Additional prompt	Demonstration items	Test format	Response required
pa1: Accept. judgements	20	real words/ nonwords	pictures	4	judgement	verbal; good/silly
(inc. correction scores)	(30)				(production)	(verbal; naming)
pa2: Phoneme identification	30	real words	pictures	4	manipulation; segmentation	verbal; yes/no
pa3: Rime judgement	20	real words/ nonwords		3	deletion	verbal; yes/no
pa4: Feature analysis	20	syllables (cv)	feature prompt	5	judgement	nonverbal; pointing

4.8. SPEECH PROCESSING ASSESSMENT

The current study employed two measures of speech processing to act as measures of phonological processing abilities, and as predictor variables for phonological awareness; an assessment of speech perception (the input dimension) and an assessment of speech production (the output dimension). The underlying theoretical considerations and the construction of the pilot tests for these two assessments will now be considered separately.

4.8.1. Speech Perception Assessment (AD)

4.8.1.1. Introduction

As with the other tests the literature provides clues as to the optimum design of a test of speech perception. Barton (1980) argues that a true estimate of children's discriminatory abilities will only be gained by a 'simple' (p108) test. If what is required is a test on which the scores are spread across the possible range, then it is wise not to make the task too long or to complex for the subject's true abilities to be revealed. It was this consideration that led to the decision not to utilise Morgan Barry's (1988) published test of auditory discrimination. Clinical experience has indicated that, for most children, this test is too lengthy resulting in a loss of concentration which leads to unreliable test results.

This is an interesting observation in the light of the fact that, in her earlier papers, Morgan (1984) comments on the difficulties of sustaining concentration during a lengthy test and on the consequent problem of deciding whether failure on a specific item was due to auditory discrimination difficulties or to loss of attention. (For a description of Morgan's study see section 3.2.8.) Further, Morgan (1984) defends her decision to present the stimuli spoken by the tester, rather than pre-recorded, arguing that this would permit the assessment to resemble most closely the speech tasks of everyday life. Bearing in mind problems of attention and concentration, Morgan (1984) argues that this form of presentation would present less opportunities for distraction than the constant stopping and starting of the tape machine. The problem with presenting the items live, however, is the potential for variation in pitch, intonation pattern or intensity that is created.

Several authors comment on the importance of preventing the child seeing the mouth of the examiner if the stimuli are presented by the tester (for example, Barton, 1980, Morais, 1991). Visual information would provide another source of variation. A similar constraint applies to information that might be gained from gaze should the tester be offering, for example, a choice of one from two items.

The decision to adopt the ABX[3] design adapted by Howell (1989) from Locke (1980a; 1980b) was made on the grounds that it did not place undue cognitive or memory processing loads on the subjects and that it had generally been found to be appropriate to this age group (see Locke, 1980a; 1980b) for a review of studies which have employed this methodology).

However, the deficiencies of a test of auditory discrimination which requires the subject to make same/different judgements on the basis of the presentation of two real words (as in the current study) have to be recognised. A child may fail on a test which requires two words to be compared not because of auditory discrimination difficulties but because of memory constraints which prevent the acoustic information being held in short term memory. If it seems likely that such limitations are present they can be overcome by accompanying the auditory presentation with pictorial representations of the stimuli items.

It seems most likely that this form of testing will give rise to 'false positives'; that is that children who have discrimination problems may fail to be identified. For example, it could be hypothesised that a subject with discrimination difficulties might perform relatively well on such a test by drawing upon their knowledge of word meaning to support the comparison. Use of this lexical route can be avoided by using non-word stimuli. However, there is contradictory evidence that, for some children, perception of non words is less difficult than discrimination of real words (see for example, Stackhouse and Wells, 1993)

[3]An ABX design requires the child to match the target items with one. of two, items presented subsequently.

or, that there is no difference in the processing of real and nonsense words (see Barton, 1980).

Further, as non-word stimuli require to be processed using the non lexical route, words have to be analysed at the phonemic level before the articulatory motor programme can be compiled (Snowling, Goulandris, Bowlby and Howell, 1986); in terms of Hewlett's (1990) model, the input lexicon passes information directly to the motor programmer with the perceptual target for the spoken output (see sections 3.2.2., 3.2.4. & 3.4.5. for further discussion of this model). This means that implicit phoneme segmentation has to take place making the task too similar to a measure of phonological awareness, specifically phoneme segmentation. Thus real word items were chosen, giving the additional advantage that the task was less abstract, and hopefully therefore more interesting, for a four year old child.

The stimuli items were chosen to include a range of consonantal contrasts and specifically to include the contrasts that might not be signalled in the speech of four year old children (see section 3.4. for a discussion of the development of the phonological system, and section 3.2.8. for a discussion of the link between perception and production). This choice takes into account current perspectives on speech development :-

> 'Children acquiring the phonology of a language must learn to differentiate the phonetic space along linguistically relevant dimensions of contrast, that is, distinctive features. In perception they must categorise speech segments according to the acoustic parameters that underlie the phoneme contrasts, whilst ignoring those acoustic variations that are linguistically irrelevant.'
>
> (Strange and Broen, 1980. p 117-118)

The stimulus items could not be selected on the basis of distinctions collapsed by individual children (as advocated by, for example, Chiat and Hunt (1993) for two reasons. First, the test was to be administered to upwards of 40 children and due to time constraints could not be specifically adapted for individual subjects. Secondly, by the age of four years (see section on speech processing), relatively few children will exhibit simplifying phonological processes in their speech output. Thus, the best approach appeared to be to ensure that the test items included contrasts liable not to be signalled in the speech of four year old children, specifically the w/r/ and /f/0/ contrasts. All contrasts occurred in syllable initial position with the remainder of the syllable, for each pair, having a constant rime. This format avoids variation due to the likelihood, noted in several papers, that syllable position affects ease of discrimination (see, for example, Barton, 1980; Walley, Smith and Jusczyk, 1986).

The items selected were all deemed to be within the vocabulary of 4 year old children; to be, within each pair, of roughly equal familiarity to avoid a frequency or familiarity effect; and to have readily recognisable pictures. Barton (1980) remarks on the likelihood that a child faced with an unfamiliar word and an unknown picture will show a tendency to link those two. Finally, the test chosen did not require a verbal response to avoid the difficulty in interpretation that might arise from pronunciation problems which mask auditory discrimination skills.

Therefore, to meet the need for a speech perception test which minimises the demands placed on other phonological processing skills, the task chosen did not require a verbal response, used real word stimuli and did not place a heavy load on phonological memory.

4.8.1.2. Construction and piloting of Speech Perception Assessment

This assessment was adapted from one used by Howell (1989). The format was an ABX design. The participants were auditorily presented with a minimal word pair with one feature difference (for example `tea' `sea'). The researcher held two glove puppets and spoke each of the minimal pair words from, behind one or other puppet. The child was asked to match a second presentation of one of the words to the appropriate puppet (i.e. which puppet said `tea'?). The child was unable to see the researcher's mouth during the presentation of the initial pair of words. The researcher's gaze was fixed on the child (and hence not on the puppets) during the presentation of the items. As a response the child was required to point to a puppet, thus avoiding the need for a spoken response. The instructions also avoided the words 'same' and 'different' to preclude problems due to children not having these items well established within their vocabulary (Bishop and Bird, 1992).

The instructions proved successful with the pilot group. However, the 40 item test proved difficult to administer as the children often lost concentration, with one child refusing to complete the assessment. Performance was deemed not to reflect auditory skills but attention control. Therefore, the children were given a second form of this assessment, a 20 item subset selected from the original 40 items to cover the range of consonantal oppositions profiled in the original test.

The contrasts included in the 20 test items of the final version of the test were three contrasts of place for stops and fricatives (/t/p/, /b/d/, and /f/θ/, four contrasts of manner (/d/z/, /s/t/, /w/r/, and /p/m/, and three voicing contrasts (s/z, /p/b/ and /g/k/). (The stimuli items and score sheet can be seen in Appendix 2.) The order of presentation was chosen at random. Each pair was presented twice during the test so that each item in the pair was the target at some point.

The results from the twenty item subset were compared with the original 40 item assessment and found to give a very similar picture with very few children in the pilot group scoring more than two errors on the shortened test and four on the longer test. Thus the shorter form was adopted.

4.8.2. Speech Production Assessment (EAT)

4.8.2.1. Introduction

Models of speech processing such as those of Hewlett (1990) and Chiat and Hunt (1993) (see section 3.4.5. for a fuller discussion) have attempted to 'capture' the multi-componential nature of speech processing skills. Once a word has been selected from the lexicon, its coding into speech involves several stages. Grunwell (1990) proposes three levels of speech production

1. articulatory movements
2. phonetic motor organisation and planning
3. phonological knowledge and organisation

Of these three levels, the first is concerned with neuromotor functioning, the third with internal phonological processing and the second with a combination of both. Within the context of this thesis it is the third level that is of primary interest. Processing at this level can be profiled in several ways.

Subjects can be asked to perform a test of homophone judgement (Kay, Lesser and Coltheart, 1992) ; that is, be asked to read a randomised (target/control) paired word list. For each pair the subjects have to judge whether they would sound the same or not if spoken. The target items are words which are pronounced similarly but spelt differently (i.e. pear/pair). Such a test is designed to provide evidence of the intactness of internal phonological representations, and of the grapheme/phoneme conversion rules.

However, this test format is not suitable for young children for two reasons. First, these subjects are not able to read word lists. Second, the interpretation of results of a test of form of internal representation becomes complex if the system is, as in the case of a child, a developing one.

More productively phonological processing has been profiled by transcribing speech output and analysing the sample for the presence of simplifying phonological rules (see section 3.4.4. for a description of these rules). The first such published analyses (for example, Ingram, 1981; Crystal, 1982, Grunwell, 1985a) involved the structured collection of spontaneous speech samples. Such procedures, whilst yielding valuable information are time consuming and later analyses (for example, Grunwell, 1987; Dean, Howell, Hill and Waters,

1990) utilised elicitation procedures to ensure that the potential simplifying phonological processes were efficiently sampled.

The advantage of such procedures is the insight offered into the constraints operating on the child's phonological system. It is, for example, possible to construct an inventory of all consonants and vowels used and to note the syllable/word positions in which they occur. Further, the simplifying phonological processes operating can be profiled (see Howell and Dean , 1994, for worked examples of such analyses).

For this study the disadvantages of such procedures lay in the constraints of the study. The literature suggested that the assessment of phonological awareness in children younger than four years might be problematic due to the inability of such subjects to perform metaphonological tests. This assumption links with the hypotheses about the age at which phonological awareness develops (see section 1.1.1.). Thus, for the sake of the assessment of phonological awareness, the subjects' age range was set at one month +/- the fourth birthday. However, by this age the phonological system of normally developing children is nearing the adult system. (For a full discussion of phonological development see, for example, Grunwell, 1981; Howell and Dean, 1994).

Howell and Dean (1994) summarise the evidence from the literature, and from their clinical studies, concerning the age at which simplifying phonological processes can be expected to disappear in normal development although Grunwell (1985a) points out that an error of six months (in either direction) in these estimates can be expected. Table 4.2. indicates the approximate ages at which individual processes are suppressed during normal development. As can be seen from Table 4.2, phonological analysis of the speech of a normally developing child aged 4;0 years old might only be expected to highlight the occurrence of four systemic (palato alveolar fronting, backing of alveolar stops, liquid gliding and fricative simplification) and one structural process (initial cluster reduction). Thus, whilst phonological analysis would appear the most satisfactory method of profiling phonological processing, another approach had to be sought for the four year old children who were the subject of this thesis.

Table 4.2. Simplifying phonological processes and the age at which they can be expected to be suppressed.

SYSTEMIC PROCESSES	Approximate age of suppression
Velar fronting	3;0 - 3;6
Palato alveolar fronting	4;0 - 4;6
Stopping of fricatives	2;6 - 3;0
Stopping of affricates	4;0 - 4;6
Backing of alveolar stops	4;0 - 4;6
Word final devoicing	3;0 - 3;6
Context sensitive voicing	2;6 - 3;0
Liquid gliding	4;6
Fricative simplification	4;6+
STRUCTURAL PROCESSES	
Final consonant deletion	3;0 - 3;6
Initial cluster reduction/deletion	3;6 - 4;0

An alternative approach to the analysis of speech production is provided by the assessment of articulatory functioning. As discussed in section 3.4.6., there is sufficient evidence of an inter-relationship between phonetic and phonological processing to make the exploration of potential articulation assessments worthwhile. Articulatory movements can be assessed qualitatively by an analysis of oral motor functioning such is provided by an oral examination (see for example, Darley, Aronson and Brown, 1975) or by instrumental analysis such electropalatography (for example, Hardcastle and Morgan Barry, 1982) or spectrographic studies (for example, Hewlett, 1985; Leonard, 1985). However, oral examination provides qualitative information which would be difficult to utilise in an analysis such as the current investigation is undertaking. Instrumental analysis requires laboratory based assessment and may involve, for example, specially constructed artificial palates. This was judged not to be appropriate for the current study due to the age of the subject group.

More pertinent to this investigation are the quantitative articulation assessments available, specifically the Edinburgh Articulation Test (EAT) (Anthony, Bogle, Ingram, and McIsaac, 1971). The over-riding advantage of the EAT is that it provides an articulation score and has been standardised on 510 children from varying social backgrounds. Further, it is appropriate for the current investigation. because it covers the age range three to six years, and because it was standardised in the same geographic area that the current investigation took place in.

Whilst the EAT fails to provide a qualitative analysis of phonological processing in terms of a process analysis, there is some overlap between the two types of procedure. For example, the EAT contains test items which give the opportunity to sample the processes 'fricative simplification', liquid gliding', 'stopping of affricates', backing of alveolars' and 'cluster reduction'; five of the simplifying phonological processes estimated to disappear last from children's output.

In addition, there is the suggestion (Hewlett, 1985, 1990; Grunwell, 1991; and see section 3.4.6.) that there may be a relationship between articulatory maturity and the presence of simplifying phonological rules. Hewlett (1985) argues that some speech characteristics (for example, simplifying phonological processes) may be best explained as resulting from avoidance strategies undertaken at the phonological level in order to circumvent lower level constraints. Indeed, the discussion of the interactions between the different components of speech processing models suggests that no one assessment can provide a completely comprehensive picture (Harris and Cottam, 1985; Hawkins, 1985; Hewlett, 1985; Grunwell, 1985b)

> '(the evidence has) demonstrated that phonetics and phonology coexist semiautonomously, but interact interdependently.'
>
> (Grunwell, 1985b. p 169)

Thus, the estimation of articulatory maturity can be argued to reflect overall speech processing skills and within the constraints of the subject group of this investigation the EAT was chosen as the most suitable test of speech production.

4.8.2.2. Assessment of speech production skills (EAT)

The Edinburgh Articulation Test (EAT) (Anthony, Bogle, Ingram and McIsaac, 1971) is a standardised test that provides quantitative information about the maturity of a child's speech production together with the opportunity to note phonological information about the child's output. The test is designed for use with children from 3;0 to 6;0 years and elicits single word production using pictures. The test is designed to provide a comprehensive picture of the child's articulation of the consonants and consonant clusters occurring in English, in various word positions and within the word structure of mono-, bi, and some multi- syllabic words.

4.9. AUDITORY MEMORY ASSESSMENT (AM)

4.9.1. Introduction

Developmental psycholinguistic approaches to language learning have emphasised the role that specific cognitive abilities, such as memory, have in helping children develop language skills. Cromer (1979) discusses Menyuk's view that a child who is unable to keep in memory more than two or three morphemes will be severely restricted in analysing that input. Consequently, internal processing and production of language will be affected.

Most studies of the early development of phonological awareness (for example, Bowey and Patel, 1988, Bryant, Bradley, MacLean and Crossland, 1989; Bryant, MacLean and Bradley, 1990; Bird and Bishop, 1992; Chaney, 1992; Warrick and Rubin, 1992) have failed to take account of memory skills. However, several papers have hypothesised a link between auditory memory, phonological awareness and reading skills (for example, Mann and Ditunno, 1990; Crain and Shankweiler, 1991; Watson and Miller, 1993). There is contradictory evidence that if intellectual abilities are controlled for, no relationship between measures of phonological awareness, phonetic recoding in working memory and/or phonetic recoding in lexical access is revealed (Felton and Brown, 1990).

The results of two studies (Howell, 1989; Naslund and Schneider, 1991) which investigated the relationship between memory and metaphonological skills illustrate the lack of clarity about the direction and nature of the link between individual processing skills (Snowling, Goulandris, Bowlby and Howell, 1986).

Howell (1989) studied four year old children (for a full description of the study see section 3.5.5.) and puts forward the convincing case for the importance of the establishment of memory traces for structural, as opposed to semantic information. However, it is difficult to see a clear connection between auditory memory and phonological awareness, within her findings, for two reasons. First, because of the overlap in the range of metalinguistic scores between the phonologically disordered group and the normally developing group, and second, because of the difficulty in estimating stored phonological information (in an imitation task) due to the output restrictions of the phonologically disordered group.

Howell's work (1989) suggests that whilst there may be a link between auditory memory and linguistic awareness for some children, for others different explanations must be sought through further investigation involving different, and more specific, tasks for assessing auditory memory. Howell (1989) suggests that one influence on her findings might have been the auditory memory task adopted - a digit repetition task- which might be supposed to make different memory demands from those required for rhyming or segmentation tasks.

Indeed, a later study by Naslund and Schneider (1991) of 61 pre-school (mean age 6;1 years), German children employed a word span test to assess auditory memory. This study found that memory capacity predicted performance on metaphonological tasks and that this relationship was maintained over time when the children were tested in the second year of school.

The findings of the studies of Howell (1989) and Naslund and Schneider (1991) support Smith's (1986) review of the literature in which he argues that phonological awareness has not yet been demonstrated to be inextricably connected to any particular component in an information processing system (for example, to phonological coding in short term memory). However, Smith (1986) argues that there is some evidence that there is an interaction between memory capacity and performance on auditory discrimination tasks.

4.9.2. Assessment of Auditory Memory (AM)

Other studies have, like Howell (1989) (for example, Watson and Miller, (1993) used digit repetition tasks to assess auditory memory. Such tests can be found in published assessments such as the Illinois Test for Psycholinguistic Abilities (Kirk, McCarthy and Kirk, 1968) or the Aston Index (Newton and Thomson, 1976). However, concerns have been expressed (for example, see 4.9.1.) about the ability of such a test to capture the memory skills which support metaphonological processing (Howell, 1989).

The word span tests employed by Felton and Brown (1990), Mann and Ditunno (1990) and Naslund and Schneider (1991) offer an alternative assessment of auditory memory skills. These tests involve the children listening to, and repeating, strings of unconnected words. Only the later study states the mean age of the children tested (6;1 years old) however with the other two studies reporting results for 'first grade' children. It was felt that such tests might prove too abstract for the subject group, aged 3;11 to 5;0 years, involved in the current study.

Thus, for the first phase of the current study, the Sentence subtest from the WIPPSI-R (Wechsler, 1990) was used (see section 4.12. below for further discussion of the WIPPSI-R). The Sentence subtest requires the child to repeat sentences of increasing length and complexity. This subtest is one of those yielding the WIPPSI-R verbal quotient and thus is completely separate from the WIPPSI-R subtests used to measure non-verbal intellectual functioning.

4.10. ASSESSMENT OF FAMILY BACKGROUND (FB)

4.10.1. Introduction

Social factors are one of the most controversial dimensions of variation in child language and much has been written on the topic of family background (FB) and language development. Many hypotheses have been put forward about the nature of the relationship between FB and emerging language skills. Wells (1986) summarises these into two main groups as follows:-

- that children from less advantaged social backgrounds are later in acquiring control of the dialect of their community
- that children from less advantaged social backgrounds are more likely to use restricted speech variants and to have restricted code orientation towards context-dependent, particularist meanings.

The second hypothesis was put forward as an alternative to the first. Labov (1979), drawing upon studies of Black American English, argued persuasively that evidence that had been taken as reflecting a deficit was in fact systematic differences in dialectal use.

Further, there is a considerable body of evidence that children can make allophonic/phonetic adjustments to their speech in response to socio-linguistic context. To give one example, Genishi and Dyson (1984) report the example of Alex, a black American child in a rural school in south Georgia. He was able to alter his production (i.e. of 'dat' to 'that', 'skreet' to 'street' and 'goin' to going') in response to a more formal context. Genishi and Dyson (1984) also present examples of parents' awareness of the issues raised by the debate on the phonology of Black English:

> 'Why is street English, or whatever it is, why is that important at all? Or why should it be important? Like the way my mother speak - she's always spoken all broken up, and she's never cared one way or the other - for the same reason that she's never voted. So what? But why is it important to speak, uh, wrong - uh, not wrong- it's a different language. Why is it important to speak a slave language?'
>
> (Genishi and Dyson, 1984. p72)

Evidence from several later studies has reflected a complex picture of the relationship between family background and language processing skills. For example, Wells (1986), in the Bristol study, found that there was no relationship between FB and language skills when FB was calculated in the form of four divisions of a scale of family background. However, when the individual family background scores were used in the analysis, a significant relationship ($p<.0001$) was obtained between family background and rate of development.

Similarly, Bryant, Bradley, MacLean and Crossland (1989) found that the mother's educational level was a powerful predictor of their children's reading levels suggesting that estimates of family background should not just take account of financial data but also educational level. Bryant, et al (1989) present an interesting study as most other investigations of family background have focused on the relationship with semantic and syntactic development. For example, Turner (1993) presents evidence for a similar relationship between maternal speech and the child's semantic processing skills.

In a study which has the relationship between family background and linguistic awareness as a specific focus, Chaney (1994) investigated 43 children with a mean age of 3;8 and found (Chaney, 1992) that oral language was the most powerful predictor of linguistic awareness (see sections 2.3.4.5. & 3.5.1. for further discussion of the findings of this study). Chaney (1994) explored the influence of socio-economic factors. She administered a questionnaire to each family to investigate 'literacy involvement'; i.e. amount and type of material read in the family, purposes served by reading at home, location of reading and writing material, use of local library and use of literacy for work/entertainment purposes. Chaney (1994) also assessed print awareness; early knowledge of letters and words, and familiarity with the mechanics of book reading.

Chaney (1994) found that income and maternal education were correlated with the rating of 'literacy involvement'. Family literacy was also highly correlated with the subjects' overall linguistic level and with print awareness. When oral language level was controlled for, print awareness was still related to linguistic awareness, and was associated with family literacy experiences and maternal education. However, family literacy and socio-economic factors had a negligible effect on metalinguistic processing when general language skills had been controlled for statistically

4.10.2. Assessment of Family Background (FB)

In the current study, family background was calculated using the socio-environmental formula devised by Wells (1981, 1982). This formula takes into account father's and mother's current (or if none, previous) occupations (using the Registrar General's occupational categories) and the level of education (measured by age of leaving full time education) of both parents. This information was gathered at the same time as permission was given for the subject to take part (see Appendix 1 for the form). The formula is:-

FB = father's occupation + mother's occupation + 2(father's educational level) + 2(mother's educational level)

Numerical values are assigned to each part of the formula. A score is then obtained for each subject which can be converted into an FB group, 1 to 4.

4.11. ASSESSMENT OF AUDITORY ACUITY

4.11.1. Introduction

Auditory acuity is of undeniable importance in the development of normal speech processing skills. If a child is unable to hear individual speech sounds then the ability to process and eventually produce those sounds will be affected. At one extreme of the continuum will lie children with sensori-neural or conduction hearing losses due to structural or neurological impairment. At the other, the many children who suffer, often intermittently, with hearing difficulties of a transient nature, for example middle ear infections. It is generally accepted that 40% of the population have hearing difficulties of a more or less transient nature at some time in their development (see for example Gibbon and Grunwell, 1990; Bishop, 1992) although the relationship between intermittent hearing loss and speech and language development is not clear (Bishop and Edmundson, 1986). There has been little investigation of the linguistic awareness of hearing impaired children; see Gartner, Trehub, and Mackay-Soroka (1993) for further discussion

4.11.2. Assessment of auditory acuity

The selection criteria for the study excluded children with known hearing difficulties. Further, parents of all children filled in a 21 item- questionnaire (taken from Howell, 1989) (see Appendix 2) giving information about the subjects' response to non-speech and speech sounds. No child had to be excluded from the study on the basis of the questionnaire answers. In addition, the investigator (a qualified speech and language therapist) monitored each child, during testing, for signs of hearing impairment.

4.12. ASSESSMENT OF NON-VERBAL INTELLECTUAL FUNCTIONING (WIPPSI)

The Wechsler Preschool and Primary Scale of Intelligence - Revised (WIPPSI-R) (Wechsler, 1990) is a series of individual ability tests designed for children from 4;5 years old to 6;0 years. Each subtest begins with the easy items and progresses to more difficult ones. The subtests can be combined into different groupings to yield

- a total quotient
- a verbal quotient
- a non verbal quotient.

The subtests yielding the nonverbal quotient were used in this study. It is necessary to separate nonverbal from verbal performance to avoid misleading correlations between variables (see section 4.13 which discusses the correlation between WIPPSI and BPVS scores). Relatively few studies of phonological awareness have considered the influence of intellectual skills but the WIPPSI-R (or the original form of the WIPPSI) has been utilised by several British studies that have (for example, Howell, 1989; Bird and Bishop, 1992).

Within the context of this thesis the purpose of administering the WIPPSI-R was to account for the possible influence of general, nonverbal, intellectual abilities. Without this control there would be the risk that any observed correlations between the dependent and independent variables are spurious, reflecting nothing but a common factor of intellectual maturity (Lundberg, 1991). (See section 2.2. for a detailed discussion of the inter-relationship between cognitive and metaphonological skills.

4.13. ASSESSMENT OF LANGUAGE PROCESSING SKILLS (BPVS)

These were estimated using the British Picture Vocabulary Scale (BPVS) (Dunn, Dunn, Whetton and Pintilie, 1982). This test measures semantic skills, namely receptive vocabulary, by asking children to point to one named picture from a choice of four. The British Picture Vocabulary Scale is designed for children from 3;0 years old to adulthood. It (or a version designed for a specific culture) has been used extensively in studies of phonological awareness (for example, Bradley and Bryant, 1983; Bowey and Patel, 1988; Bryant, Bradley, MacLean and Crossland, 1989; Bryant, MacLean and Bradley, 1990; Bird and Bishop, 1992; Chaney, 1992; Warrick and Rubin, 1992). (See section 2.3. for a detailed discussion of the inter-relationship between metaphonological and linguistic variables).

4.14. ASSESSMENT OF LITERACY SKILLS (ST)

The first phase of the current study was focused on non-readers to avoid the variability that would be introduced by emerging literacy skills. Ability to read was screened using the Schonell Graded Reading test from the Aston Index (Newton and Thomson, 1976). The children were required to read out a series of graded words. Each child was deemed not to have any reading skills if none of the first twenty words in the test could be recognised. (The normative data provided in the test suggests that 0-1 words read correctly gives a reading age of less than 6;0, and 20-21 words read correctly gives a reading age of 7;4 years.)

4.15. PILOT STUDY: ADDITIONAL CONCLUSIONS

The overall length of the assessment battery proved difficult for some children in terms of the attention control required. It was essential to spread the tests over several sessions which (within the time span restrictions of the study) increased the potential risk of losing subjects due to illness, holidays etc. The assessment schedule and the study design required a number of tests to be completed within a short time span. However, permission was given for all subjects contacted to be included in the pilot study and none of the subjects involved in the pilot study failed to complete testing within the target time period.

The pilot study also allowed some overall conclusions to be drawn about the optimum conditions for testing. Alternative accommodation was sought in one nursery school because of unacceptable noise levels. It was recognised that testing children in their own homes did not provide the best conditions. The children tended to be more distracted, the physical conditions less suitable (in terms of furniture, power point location, interruptions etc.) and the testing took much longer due to the need to liaise with parents. The first experiment, reported in the next chapter took account of these conclusions in the design of the test situation.

4.16. SUMMARY

This chapter has reported the outcomes of the piloting procedures which preceded the main investigation. The overview of the literature presented in Chapters 1 - 3 provided the basis for the design of the measures employed in this investigation of the strength and nature of the relationship between phonological processing and phonological awareness. Chapter 5 reports the first phase of the study; Experiment 1.

CHAPTER 5
Experiment 1

5.1. AIMS

1. To explore the nature of phonological awareness in four year old children
2. To determine the variables which influence phonological awareness

5.2. DESIGN

This phase of the investigation involved the testing of the subject group, on a battery of assessments, within a given time period. The subjects' performance was analysed using univariate, bivariate and multivariate statistical analyses.

5.3. ETHICAL APPROVAL

Ethical approval for the study was given by the Ethics Committee of Lothian Region Education Department and by the Ethics Committee of Queen Margaret College.

5.4 SUBJECTS

5.4.1. Sample size

The sample size was based on a calculation of the Confidence Intervals that would result for a given correlation. The decision about the size of correlation that would be acceptable can be made on the basis of previously published studies (Altman, 1991). However, as discussed in section 2.1, only a very few of those studies reported in the literature are directly relevant as few focus on phonological awareness. A decision was therefore made to adopt a correlation coefficient of 0.5. The Confidence Intervals for a correlations of 0.4, 0.5 and 0.6 at different sample sizes are given in Table 5.1. As the Confidence Interval does not reduce markedly for an increase in sample size up to 100, the decision was made to test a sample of 50 in some detail and to accept a Confidence Interval (for a 0.5 correlation) of 0.26 - 0.68.

Table 5.1: Examples of Confidence Intervals for different sample sizes and correlation coefficients

r =	0.4	0.5	0.6
N			
50	0.14 - 0.61	0.26 - 0.68	0.39 - 0.75
60	0.16 - 0.59	0.28 - 0.67	0.41 - 0.74
100	0.22 - 0.55	0.34 - 0.63	0.46 - 0.71

5.4.2. Selection criteria

1. No known hearing, visual or neuro-motor impairment
2. Not able to read any item on a single word reading test
3. Not bilingual

5.4.3. Subject group

The outcome, due to practical constraints[1], was that 46 children were tested during Experiment 1; 21 boys and 25 girls. All the subjects were, with four exceptions, seen within four weeks of their fourth birthday. Testing for the four exceptions was completed within six weeks of their fourth birthday.

Under the terms of the ethical approval the state schools to be involved were nominated by the regional Education Department after discussion with the researcher. Contact was made with the subjects via the head teachers and nursery teachers at three local authority primary schools and two private nurseries; and by contacting parents whose children either attended a parent-run play group or had earlier been involved in the Child Study projects of first year Speech and Language Science students.

All children from these sources who reached the appropriate age during the period of testing (December 1993 to September 1994) were contacted (see Appendix 1 for copies of

[1]The practical constraints were related to the number of children requiring to be tested within a given time period.

specimen letters). Only one refusal was received and this parent, according to the head teacher, never gave permission for the child to take part in any such activity. To try to gain permission from this family a second letter was sent but no reply was received. Three children who would have been eligible, and whose parents had given permission, were not tested due to practical constraints relating to the number of children requiring to be tested during a particular month.

5.5. METHODOLOGY

5.5.1. Introduction

All testing sessions took place within quiet rooms (either within the schools or at Queen Margaret College) where the children could concentrate and listen, and where a tape-recording of reasonable quality could be made. Some children were seen both within the school and later at Queen Margaret College (QMC) due to accommodation difficulties within the school. Every child was seen for three test sessions, each of which lasted approximately forty minutes and which took place at weekly intervals. In some cases, when testing took place within the QMC clinic, a parent was present but all sat at a distance, behind the child, and did not participate.

5.5.2. Assessment battery

The assessment battery comprised tests of

- Phonological awareness (PA)

  This assessment was designed for the experiment and comprised 4 subtests

  1. Subtest 1: acceptability judgement (pa1)
  2. Subtest 2: onset and phoneme identification (pa2)
  3. Subtest 3: rime judgement (pa3)
  4. Subtest 4: feature analysis (pa4)

  See Table 4.1, and section 4.7 for further information about the format of these subtests and Appendix 2 for examples of the data collection sheets.

- Speech perception (AD) (Howell, 1989; see section 4.8.1.)
- Speech production (EAT) (The Edinburgh Articulation Test (Anthony, Bogle, Ingram and McIsaac, 1971); see section 4.8.2.)
- Non-verbal cognitive skills (WIPPSI) (Wechsler PreSchool and Primary Test of Intelligence - Revised (Wechsler, 1990); see section 4.12.)
- Vocabulary skills (BPVS) (British Picture Vocabulary Scale (Dunn, Dunn, Whetton, and Pintilie, 1982); see section 4.13.)
- Auditory memory (AM) (Wechsler PreSchool and Primary Test of Intelligence - Revised (Wechsler, 1990); see section 4.9.)
- Literacy skills (ST) (Aston Index (Newton and Thomson, 1976); see section 4.14.)

(See Chapter 4 for full background to, and details of, tests used.)

In addition, parents were asked to fill in a hearing questionnaire (see Appendix 2) to provide details of history of ear infections and as a further check against inclusion of children diagnosed as hearing impaired. In addition, the consent form (see Appendix 1) requested details of family background (see section 4.10), including level of parental education; languages spoken in the home; and the child's place in the family. The sex of the child was also noted.

5.5.3. Order of testing

The tests were always carried out in the same order

1. Speech perception (AD)
2. Literacy skills (ST)
3. Non-verbal cognitive skills (WIPPSI)
4. Speech production (EAT)
5. Vocabulary skills (BPVS)
6. Auditory memory (AM)
7. Phonological awareness (PA)

- acceptability judgements (pa1)
- feature analysis (pa4)
- rime judgement (pa3)
- phoneme identification (pa2)

The order was chosen on the basis of the investigator's clinical experience and confirmed by the pilot study. The order of testing alternated, as far as possible, tests requiring verbal and non verbal responses, and tests found more, or less, interesting by the children.

5.6. RESULTS: INTRODUCTION

A spreadsheet with the full data set is in Appendix 3. Six of the explanatory variables are in the form of categorical data (sex; history of ear infections; place in family; family background; maternal and paternal educational levels) and dummy variables were created to code these.

The data analysis is presented in three sections which cover univariate, bivariate and multivariate analyses (see Appendices 4, 5/6, and 7 respectively). The data was collated using an Excel spread sheet and imported into SPSS for analysis. Texts used to inform the data analysis included Altman (1991), Cramer (1994), Erickson and Nosanchuk (1992), Everitt and Hay (1992), Foster (1993) and Norusis (1993). Overall, a 95% confidence interval was adopted, with a cut off level for statistical significance of 0.05.

5.7. RESULTS: UNIVARIATE ANALYSIS

5.7.1. Categorical Data: Distribution

This information is summarised in Table 5.2.

Table 5.2: Summary of background information for subjects in Experiment 1

	YES	NO	N=
History of ear infections (AUD)	19	21	40
Older siblings (PL)	26	20	46
Mother with full time post school education (MED)	28	18	46
Father with full time post school education (PED)	28	18	46
Bilingual	0	46	46
Literate	0	46	46

Sex (SX)

There were 21 boys and 25 girls in the study.

History of ear infections (AUD)

The parental questionnaires were coded for evidence of a history of ear infection. This evidence was used to divide the children into those who did and did not have such a history. Five questionnaires were not returned despite prompting, and one questionnaire was spoilt. Appendix 4 presents data for 40 children. 19 children were coded as having had evidence of a history of ear infections and 21 had no such history.

Family background (FB)

21 of the children came from families calculated to be in the social grouping FB1, 19 in FB2 and 6 from FB3. The latter group was so small it was not included in the bivariate analyses.

Level of parental education (MED, PED)

28 of the children had mothers who had had full time education post school and 18 did not. The mean age for the mothers to have left full time education was 19. 28 of the children had fathers who had been in full time education post school. The mean age for fathers to have left education was 22.

Place (PL)

20 of the children (including one set of twins; S 25 and 26) had no older siblings and 26 did.

Bilingualism

It was ascertained, from the information provided by parents, that no child in the study was bilingual; that is, spoke or understood a language other than English. However, some parents noted that their child might have had minimal exposure to another language. For example, one parent noted that German songs were sung in the home and one mother spoke Gaelic as a second language.

Literacy (ST)

No subject tested could read any item on the reading test.

5.7.2. Interval data: distribution

Table 5.3 summarises the raw scores for the group on each test yielding interval data. (For further summary statistics, and stem and leaf plots of the distribution of each measure see Appendix 4.)

Table 5.3: Numerical summary of raw data from tests of phonological awareness (PA), speech production (EAT), vocabulary (BPVS), non-verbal cognition (WIPPSI), speech perception (AD) and auditory memory (AM).

Test	Mean	95% Confidence Interval	Median	Variance	Std deviation	Min	Max
PA	70.39	67.92, 72.86	70.50	69.09	8.31	49	86
EAT	54.65	52.18, 57.11	58.00	68.81	8.30	28	67
BPVS	40.15	36.9, 43.41	42.00	119.99	10.95	16	69
WIPPSI	89.26	82.36, 96.16	88.00	539.31	23.22	26	134
AD	16.43	15.74, 17.12	17.00	5.41	2.32	10	20
AM	13.85	12.5, 15.2	13.00	20.67	4.55	6	29

While these plots, and the summary statistics, indicated that the variables had satisfactory distributional properties the data was transformed to log scores to ensure that it met the criteria for parametric statistical analysis as well as possible (Everitt and Hay, 1992; Cramer, 1994)

5.7.2.1. Outliers

No one subject consistently scored outside the range of the distribution although three subjects (S 8, 34, 39) scored as outliers on two tests; subject 8 on the WIPPSI and the EAT, subject 34 on the AD and BPVS, and subject 39 on the AM and the BPVS. In addition, the score of subject 15 was an outlier on the EAT, and that of subject 45 on the AM (see Appendix 4).

The outliers were not removed from the analyses for two reasons. First, the same subject did not constitute an outlier on more than two tests, and second, it was considered that valuable data would be lost by not taking account of these subjects' performance.

5.8. RESULTS: BIVARIATE ANALYSIS

5.8.1. Differences between means

The data was analysed to investigate whether there was a significant difference on the variables phonological awareness (PA), speech production (EAT), speech perception (AD), auditory memory (AM), vocabulary (BPVS), non-verbal cognition (WIPPSI) for groups of subjects who

- were boys/girls (SX),
- came from family backgrounds 1/2 (FB)
- had mothers who did/did not have post-school education (MED)
- had fathers who did/did not have post-school education (PED)
- did/did not have older siblings (PL)
- did/did not have a history of ear infections (AUD)

One way Analyses of Variance were carried out on the transformed data (for the full analyses see Appendix 5). For a discussion of the distribution of the scores on individual variables see section 5.7. The assumption that the groups had equal variances was tested using Levene's Test for Homogeneity of Variance. Assumptions that the variances were equal could not be made for the following comparisons:-

Table 5.4: Variables which did not have equal variances

	PA	EAT	BPVS
FB	*	*	
MED		*	
PED			*2
PL	*		

A 95% confidence interval was adopted. An F probability of less than 0.05 was taken to indicate a significant difference between groups (Altman, 1991)

There were no significant differences between the groups who did and did not have a history of ear infections (AUD), or between the groups who did or did not have older siblings (PL). Table 5.5 summarises the significant differences that were found.

Table 5.5: Significant differences between means for groups with differing levels of maternal (MED) and paternal (PED) education, different family backgrounds (FB); and different sexes (SX).

	WIPPSI	EAT	BPVS	AM
FB			.0451	.0024
MED				.0180
PED				.0032
SX	.0034	.0336		

5.8.2. Differences between groups of subjects with high/low phonological awareness

To examine the difference between the subjects with high, and those with low, phonological awareness the subject group was divided into two subgroups comprising the 15 subjects

[2]There was a significant difference in the BPVS scores of the groups who did/did not have fathers who had had post school education (.0196). Whilst these groups did not have equal variances, the result is worth noting as the ANOVA is a robust test and consequently the data does not have to meet the equality of variance assumption perfectly.

with the highest phonological awareness and the 15 with the lowest (as measured on the test of phonological awareness).

As there were relatively small numbers of subjects in each group, the decision was made to carry out a series of independent t tests to determine whether the means of the high and low phonological awareness groups differed with regard to each of the independent variables. Nine independent t tests were carried out (see Appendix 5) The equality of the variances in the two samples was calculated using Levene's Test. A 95% confidence level and a cut off level for statistical significance of 0.05 were adopted.

There was a significant difference between the samples of subjects with high and low phonological awareness on the tests involving speech perception (AD) ($p<0.001$), auditory memory (AM) ($p<0.001$) and vocabulary skills (BPVS) ($p<.0.003$).

5.8.3. Correlation coefficients: interval data

The extent to which any of the variables measured on interval scales correlated was calculated using the parametric measure Pearson's product moment correlation coefficient. (Transformed data was used in all correlations.) The results are represented in a correlation matrix in Appendix 6. Table 5.6 summarises the significant correlations.

Table 5.6: Significant intercorrelations between phonological awareness (PA), speech perception (AD), speech production (EAT), auditory memory (AM), vocabulary (BPVS) and nonverbal cognition.(WIPPSI)

	PA	AD	AM	EAT	BPVS
AD	.4817 p<.001				
AM	.4065 p<.005	.4624 p<.001			
EAT	.3894 p<.007	.4895 p<.001	.3626 p<.013		
BPVS	.4492 p<.002	.5338 p<.001	.5848 p<.001	.4586 p<.001	
WIPPSI			.5924 p<.001	.5179 p<.001	.5281 p<.001

5.8.4. Correlation coefficients: categorical data

However, not all the variables are measured by interval scales (for example sex (SX), family background (FB), maternal education (MED), paternal education (PED), presence of older siblings (PL.). These constitute categorical data and are included in the correlational analysis by using Spearman's rank order correlation coefficient. The resulting matrix is presented in Appendix 6. The significant correlations are presented in Table 5.7. Phonological awareness (PA) did not correlate significantly with any of the variables in this analysis.

Table 5.7: Significant intercorrelations between speech production (EAT), auditory memory (AM), vocabulary (BPVS), nonverbal cognition (WIPPSI), sex (SX), family background (FB), maternal education (MED), paternal education (PED) and presence of older siblings (PL).

	AM	EAT	BPVS	WIPPSI	FB	PED
FB	-.4468 p<.002		-.3766 p<.010			
PED	.3712 p<.011		.2925 p<.049		-.7262 p<.001	
MED	.3459 p<.019		.3346 p<.019		-.6527 p<.001	.5437 p<.001
SX		.3497 p<.017		.4078 p<.005		

5.8.5. Summary

However, the limitation of bivariate, or correlational, analysis is that causation is not implied. If Factor A and B appear to be related it could be because both are related to a third, perhaps unaccounted for, variable that produces the variation in both Factors. A and B. A multivariate analysis was therefore carried out (see section 5.9).

5.9. RESULTS: MULTIVARIATE ANALYSIS

5.9.1. Introduction

Regression analysis estimates, or predicts, scores on one variable (called the criterion, or dependent, variable from one or more other variables (called predictors or independent variables). In order to predict the criterion it is related to, or regressed onto, the predictor variables. (Altman 1991). In this study regression analysis was used to estimate the relationship between the dependent variable phonological awareness and the independent variables speech perception, speech production, auditory memory, vocabulary, non verbal cognitive skills, sex, family background, position in family and level of parental education.

To use regression analysis three assumptions have to be made (Altman, 1991)

1. that the values of the dependent variable should have a normal distribution for each value of the predictor variable X;
2. the variability of the dependent variable as assessed by the variance should be the same for each value of X;
3. the relation between the two variables should be linear.

A visual impression of whether the data deviates from these conditions can be gained from a scatter plot of standardised predicted values against standardised residuals. As can be seen from Figure 1 (Appendix 7) the plot of residuals shows the points evenly scattered at all X values with no evidence of any relationship. In addition the Normal plot of the residuals allows a formal assessment of the assumption of normality. Figure 2 (Appendix 7) shows that the plotted residuals do not deviate from the regression line.

As there is only one variable in the equation the issue of colinearity (see section 6.12.) is not relevant.

5.9.2. Analysis

Multiple regression using the stepwise method identified speech perception (AD) as being the variable which contributed most highly to the variance in the dependent variable phonological awareness (PA). (See Appendix 7 for analysis.) The overall correlation between the predictor variables and the dependent variable was .50868 (Multiple R) suggesting that the combination of predictor variables selected accounted for almost half the variation in the phonological awareness scores. An R squared of .25876 indicated the proportion of the variability in the dependent variable that was accounted for by the multiple regression equation. This was corrected (Adjusted R squared) to .23925 for the population as a whole (rather than the sample) and includes a correction for shrinkage.

The analysis of variance gives the sum of squares explained by the regression equation and the 'residual' sum of squares. The latter (.46477) is the variability in the dependent variable left unexplained by the regression equation.

The significance of the F statistic (.0008) allows the assumption that there is a linear relationship between the predictor and the dependent variable and thus that the regression equation allows the prediction of the dependent variable at a level greater than chance.

The B value (.386383) represents the regression coefficient for each variable, determining how much weight is given to each of the predictor variables. However, the relative importance of the coefficients is indicated by the Beta value (.508682) which represent the transformation of the B value into a standard scores. If more than one predictor variable was present in the equation the Beta values would indicate which had more influence on the dependent variable.

The T value (sig. T .0008) indicates that the regression coefficient for the predictor variable speech perception is greater than zero and therefore that it will predict phonological awareness (PA).

Vocabulary (BPVS) and speech production (EAT) scores account for the next most important proportions of variation (sig. T. .0725 and .0770 respectively). However, it would be a mistake to conclude that these variables were unimportant. Within the stepwise method the computer will automatically enter the variable which has the highest correlation with the dependent variable. As already discussed the variable entered first into the equation will always have a higher contribution to the total. Thus, the variable which is first included in the analysis will have a significantly higher contribution than those that follow.

5.10. UNIVARIATE ANALYSIS OF THE SCORES ON DIFFERENT SUBTESTS OF THE PHONOLOGICAL AWARENESS TEST (PA)

Table 5.8 summarises the distribution of the scores on each of the subtests making up the test of phonological awareness. Appendix 4 provides stem and leaf plots, and further data. The criterion level for passing the phonological awareness subtests was calculated using the binomial distribution. This was possible because three out of the four subtests involved a binary (yes/no) choice. For the fourth subtest (acceptability judgements), which involved a binary choice for acceptability and also a correction task, the binomial criterion could only be established for the acceptability judgements. Any response involving production (as the correction tasks does) involves an unknown but infinite number of possible answers and therefore the probability of a correct answer by chance would be very low (Chaney, 1992).

Table 5.8: Numerical summary of raw data from the subtests of the Phonological Awareness Test (PA).

SUBTEST	Mean	95% Confidence Interval	Median	Variance	Std dev.	Min	Max	% Pass Rate
Acceptability. judgements[3]	26.78	25.39, 28.17	28	21.95	4.69	10	30	93.48
Phoneme identification	15.59	14.95, 16.24	15	4.87	2.21	11	25	2.3
Rime judgement	11.74	10.87, 12.61	10	8.51	2.92	8	19	19.57
Feature analysis	16.09	15.08, 17.09	16.50	11.46	3.39	8	20	65.22

The critbinom formula (Excel) calculates the smallest integer for which the binomial distribution is greater or equal to a criterion value (alpha). In this analysis alpha was taken as 0.99 resulting in a significance level of 1%. That is, a child would be highly unlikely to

[3] Criterion pass rate calculated for acceptability judgements only (see section 5.10.).

have obtained such a score (and therefore deemed to have phonological awareness) by chance.

5.10.1. Acceptability judgements (pa1)

This proved the easiest of the tests with 93.48% of the four year old subject group reaching criterion (a score of 19). The total subtest score was made up from detection and correction scores with the percentage of correct answers on the detection task (out of the total number of items) being 92.6% whilst the total number of correct items on the correction task was 82.8%.

Thus, for the children in this study there was some weak evidence that 'correction' was a more difficult task than 'judgement'. However the numbers cannot be compared directly as there were twice as many opportunities to make judgements as to make corrections.

5.10.1.1. Types of explanation

The children were also asked to provide an explanation for their detection of error. These explanations were transcribed and then analysed into five categories which arose from study of the data and were related to the focus of the explanation and not to its semantic or syntactic form. (See Appendix 4.) The categories were non-specific: unrelated; non-specific: speech related; meaning centred; word centred and segment centred. These will now be defined and examples provided[4].

[4]In these examples, as in Appendix 4, the following notation is used; '+' = the correct pronunciation produced by the tape recorded speaker; 'x' = the mispronunciation as produced by the tape recorded speaker; '++' = the correct pronunciation correctly reproduced by the child; '+-' = the correct pronunciation incorrectly reproduced by the child: 'x+' = the mispronunciation correctly reproduced by the child; 'x-' = the mispronunciation correctly reproduced by the child.

5.10.1.2. Non-specific explanations

These explanations were divided into those that did not explicitly refer to the word heard, or the recorded speech (non-specific: unrelated), and those that which specifically mentioned speech or hearing (non-specific; speech related)

Examples: unrelated explanations
' I just did ' (7)
' easy ' (8)
' 'cos I just know ' (3)
' 'cos I don't know how she was going to do it ' (43)
' because that means a silly girl ' (25)
' 'cos my mummy didn't tell me I guessed ' (28)
' 'cos it was just wrong ' (46)

Examples: speech related explanations
' 'cos said a wrong word ' (14)
' I heard it ' (10)
' I heard it on the tape ' (4)
' 'cos she said it' (1)
' because I heard her saying, what was that? ' (13)

5.10.1.3. Meaning centred explanations

This category included those comments which rejected items on the basis of meaning alone.

Examples:
' 'cos it was not like "lamb" ' (15) (stimulus picture was a goat)
' 'cos it was a spoon ' (15)
' no that's a cup, it's the same shape as a cup ' (25)

5.10.1.4. Word centred explanations

The comments included in this category were those in which the subject specifically mentioned either the mispronounced or the correctly produced form, or those in which the subject commented explicitly on the correctness/incorrectness of the item.

Examples:
' because you have to say (++) ' (1)
' because she said (x+) ' (18)
' she call it, we call it (++) (26)
' no, that was (x+), it was wrong ' (46)
it was silly because she didn't say (++) ' (46)

5.10.1.5. Segment centred explanations

This category included those instances when the subject made an explicit comparison between the incorrect and correct form; either by producing both forms or by explanation.

Examples:

' she said (x+) instead of (++) ' (35)
' because if she said (x-), she needs to remember it's (++) ' (40)
' because she said (++), quite she did but quite she didn't, she should have said (++) ' (1)
' because it was supposed to be (++), she said (x-) ' (14)
' 'cos they're (++) and she said (x+) ' (37)
' it nearly started like, I'll have to listen again ' (43)
' 'cos (x+) isn't a (++) ' (44)

5.10.1.6. Issues in analysis of explanations

Some of the data proved complex to categorise due to the degree of inference needed. In the case of the comment

'cos it was not long good' (when the item was /tɪ/ the mispronunciation of 'key') (S 15)

it is tempting, but probably erroneous, to infer that the subject was referring to the fact that the mispronunciation involved stopping of the initial fricative (a continuant). The decision was made to code this comment as a non-specific: speech related explanation, as opposed to a segment centred explanation.

Alternatively, the comment

'that never starts with "snake" ' (S 43)

was coded as a segment centred explanation (as opposed to a meaning centred explanation) on the grounds that there was sufficient indication that the child realised that it was the initial segment that was different in the mispronunciation.

Subjects 43 and 45 produced similar explanations;

'cos she said (++), (x+)' (S 43)

'cos she said (x-), (x+) (S 45)

A conservative coding of word centred explanation was made (which assumed that the child had had two attempts at production) as opposed to regarding the comments as referring to the difference between the two realisations.

Further explanations which require comment are those involving the word 'shape'. Subject 25 said

> 'no, that's a cup, its the same shape as a cup.'

This comment was coded as a meaning centred explanation. However, Subject 38 explained

> 'cos it wasn't the right shape to be that, was it?

a comment that coded as a segment centred explanation. The reason for this division was the circumstances surrounding the testing. Child 25 appeared to be referring to the picture, as is suggested by the verbal output. On the other hand, Subject 38 appeared to refer to the sound of the word and had already turned the picture face down.

A similar comment, within a similar testing situation, was made by Subject 13

> 'it said (x-) because I heard it was the same shape as that'

suggesting, interestingly, that subjects may use the word 'shape' in an auditory context.

5.10.1.7. Other complicating factors

There were several factors which appeared to affect the type of explanation used. For example, after providing a segment centred explanation some children appeared to be influenced by the tag question 'What should she have said?'. (See section 4.7.2. for a description of the full subtest procedure). They seemed subsequently to assume that the 'correct' answer to the previous question 'How did you know it was a silly one?' should have been a correction. Gradually the explanations tended to be given as corrections; replying, for example, 'Because she should have said "stairs".'

5.10.1.8. Analysis

To account for the problems relating to both inference, and to children's assumptions, the data was analysed only by noting which types of explanation were evident. One example of a particular type of explanation was taken as evidence that the child could use this type even if they did not on produce a similar level of explanation on every turn.

6 subjects (5, 9, 12, 17, 22, 30) produced no explanation. The number of subjects utilising each level of explanation is shown in Table 5.9.

Table 5.9: Number of subjects utilising each level of explanation during subtest pa1: Acceptability judgements.

Type of explanation	Non-specific: unrel	Non-specific: sp rel	Meaning centred	Word Centred	Segment centred
No of Subjects	15	12	8	25	11

As can be inferred from Table 5.9, some subjects produced several different types of explanation (see Table 5.10)

Table 5.10: Number of levels of explanation used during subtest pa1: Acceptability judgements.

No. of types of explanation	0	1	2	3	4	5
No of subjects	6	16	18	5	1	0

No subjects produced all five types of explanation and it was most common for subjects to use 1 or 2 types. One subject (S 15) used four types of explanation. The commonest single category used was word centred explanations (9 subjects) and non-specific: unrelated (6 subjects). However, different subjects utilised different combinations of types of explanation (see Appendix 4).

Interestingly, only two subjects (10, 44) commented on the fact that there was a mismatch between the speaker's performance on each pair of items (i. e. if on the first pass through the pictures the speaker had mispronounced the stimulus item, it was correctly produced the second time). Subject 10 commented

'got it right that time!'

Subject 44 noted

' she was right the first time, but she wasn't right the next time.'

5.10.1.9. Differences between means for groups of children who did/did not produce word and/or segment centred explanations.

To investigate whether there was a significant difference (on the variables speech perception (AD), auditory memory (AM), vocabulary (BPVS), speech production (EAT), phonological awareness (PA), nonverbal intelligence (WIPPSI), history of ear infections (AUD), family background (FB), maternal and paternal post school education (MED, PED), presence or absence of older siblings (PL) and sex (SX)) for the children who could/could not provide word/segment centred explanations a series of one way ANOVAs were carried out (see Appendix 5). The assumption that the variance of both groups was equal was tested using Levene's Test for Homogeneity of Variances. This assumption could not be made for the comparison between BPVS scores and level of explanation, or between PL ratings and level of explanation.

A 95% confidence level was adopted . An F probability of less than 0.05 was taken to indicate a significant difference between the groups being compared (Altman, 1991). Table 5.11 indicates the significant differences found.

Table 5.11: Level of significant difference on the variables auditory memory (AM) and non verbal intelligence (WIPPSI) for those children who could/could not produce word and/or segment centred explanations (EXP).

	AM	WIPPSI
EXP	.0048	.0025

In addition, there was a finding of a significant difference ($p<.0011$) in the vocabulary (BPVS) scores for the children who could/could not produce word and/or segment level explanations. This finding is not presented in Table 5.11 as the data did not meet the equality of variance assumption. However, due to the 'robustness' of the ANOVA test it is worth noting this finding.

5.10.2. Pa2: Phoneme identification

This subtest proved the most difficult of all with 4 subjects reaching criterion (a score of 19) (see Appendix 4). One child was able to make no attempt at this task and was allotted a chance score of 15. 39 children adopted the strategy of replying with the same answer (yes or no) to all items. 10 children chose to reply no to all items, and 29 chose to reply yes (although 8 of these children used the other choice between 1 (5 children) and 3 (1 child) times, usually choosing the alternative answer on the second item and then reverting to the original choice).

Table 5.12: Percentages of stop and fricative phonemes correctly identified in different syllable contexts

Subject	T /15	D /15	S /8	F /7	C(s)vc /4	C(f)vc /4	Cvc /8	cvC /7
2	8	15	4	4	3	4	7	1
27	5	15	3	2	3	2	5	0
11	9	12	4	5	2	3	5	4
21	5	15	2	3	2	2	4	1
24	10	15	5	2	4	4	8	2
32	11	12	5	6	1	3	4	7
sum	48	84			15	18		
%	53.33	93.33			62.5	75		
sum			23	22			33	15
%			47.92	52.38			68.75	35.71

KEY
T = target item — D = distracter
F/f = fricative — S/s = stop
Cvc = syllable initial position — cvC = syllable final position
/x = total number of items

6 children showed evidence of attempting the metaphonological task. (See Table 5.12); i.e. did not use the strategy described above. Their performance was analysed for any trend with regard to complexity of task. This small subject group seemed more likely to judge correctly the distracter items as wrong (93.3% of possible items; N=84) than the target phonemes (53.3%; N=48).

Initial phonemes (which were also onsets) which were fricatives (C(f)vc) were easier to identify than those that were stops (C(s)vc). Comparison between overall initial and final phonemes, and between stop and fricative classes was complicated by the fact that (due to constraints of overall PA test construction) the subtest comprised 3 fricatives in syllable final position, but 4 stops in the same context. However, Table 5.12 gives percentage analyses which suggest that stops were marginally easier to identify than fricatives (overall syllable context) whilst initial phonemes/onsets were markedly easier for these subjects to identify than phonemes in syllable final position.

Table 5.13: Performance of children who were able to attempt the subtest pa2, on the Test of Phonological Awareness

Subject	SX	pa1	pa2	pa3	pa4	PA total
2	2	28	20	18	20	86
11	2	26	21	12	20	79
24	2	29	25	10	19	83
27	2	29	19	8	15	71
32	2	26	20	16	11	73
mean		27.6	21	12.8	17	78.4

Table 5.14: Performance of children who were able to attempt the subtest pa2, on the independent variables

Subject	EAT	BPVS	WIPPSI	AM	AD	FB	PL	AUD	MED	PED	EXP
2	56	50	80	17	19	2	1	0	0	0	1
11	48	31	69	15	14	1	1	1	0	1	1
24	67	43	97	11	17	2	0	0	0	1	1
27	64	41	125	13	18	2	0		0	1	1
32	60	23	109	11	17	2	0	1	1	0	1
average		78.4	59	96	13	13.4	17				

When the level of difficulty of this tasks became apparent (after 9 children had been tested) the procedure was modified slightly. The children were asked, in the introduction, to segment their own name. Subsequently, if the subjects were unable to complete the task of pa2, their performance was scored and they were then asked whether they knew what sound each of the picture names began with. Interestingly, 17 of the 37 children asked could segment their own name. In response to the pictures, 5 could produce the correct initial phoneme with a schwa vowel, and 6 could produce the correct initial phoneme and the appropriate following vowel.

5.10.3. Pa3: Rime judgement

This test was the second hardest with 19.6% of the children reaching criterion (a score of 14). The test items were divided into word (e.g. 'head') and non word (e.g. 'med') rhymes with the target 'Ed' and word (e.g. 'fat') and non word (e.g. 'wat') distracters.

Overall, there was little difference in performance on the word, and non word, items with a total of 266 correct answers for word items (target and distracter) with 274 correct answers for non word items. (Total possible correct items = 920).

5.10.4. Pa4: Feature analysis

This was the second easiest subtest with 65.2% of children reaching criterion (a score of 14). Because subtests of this type have not been employed in studies of phonological awareness before the Feature Analysis subtest was administered to a group of first year College students who had no knowledge of phonetics. First, in order to evaluate the acceptability of the recording, these students were asked to write the appropriate letter for each consonant they heard. The range of correct answers was from 17 to 20 with one student performing as an outlier and scoring 15. If this student is disregarded, the average score is 18.6 with the median and modal scores both being 19. The most common error was that /g/ was identified as 'd'; perhaps a result of the decontextualised presentation.

Second, the students were given exactly the same instructions as the children and asked to complete the task by judging whether each item was a 'Mr Noisy or a Mr Whisper' sound. The average score was 17.70, the median score 19 and the mode 20; with the range being 13 - 20.

5.11. CORRELATION BETWEEN PHONOLOGICAL AWARENESS SUBTESTS.

Intercorrelations between the transformed data from the phonological awareness subtests and the overall phonological awareness scores were calculated using Spearman's correlation coefficient. (See Appendix 6.) The significant correlations are presented in Table 5.15.

Table 5.15: Significant intercorrelations between overall Phonological Awareness Test scores and performance on individual subtests.

feature analysis	.3289 p<.026	.2936 p<.048	-
Phonol. Awareness	.6700 p<.001	.5397 p<.001	.7033 p<.001
	accept. judgement	**rime judgement**	**feature analysis**

5.12. CORRELATION BETWEEN PA SUBTESTS AND OTHER VARIABLES.

The transformed data from the individual phonological awareness subtests and all other variables were analysed using the Spearman correlation coefficient (see Appendix 6). Table 5.16 summarises the significant correlations.

Table 5.16: Significant intercorrelations between performance on phonological awareness subtests and measures of phonological awareness (PA), speech perception (AD), speech production (EAT), auditory memory (AM), vocabulary (BPVS), family background (FB), parental education (MED, PED), position in family (PL), and sex (SX).

	pa1	pa2	pa3	pa4
AD	.4995 p<.001			.4118 p<.004
AM	.5072 p<.001			.3851 p<.008
BPVS	.5566 p<.001			.4338 p<.003
EAT		.3078 p<.037		
WIPPSI	(.2898) (p<.051)			
FB	-.3737 p<.011			
MED	.4627 p<.001		.3488 p<.017	
PA	.6700 p<.001		.5397 p<.001	.7033 p<.001
PED	(.2901) (p<.051)			
PL			.3154 p<.033	
SX		.5046 p<.001		

5.13. MULTIVARIATE ANALYSES OF VARIABLES WHICH CONTRIBUTE TO VARIATION IN PERFORMANCE ON THE INDIVIDUAL SUBTESTS OF THE PHONOLOGICAL AWARENESS TEST AT FOUR YEARS OLD.

To investigate the relationship between the independent variables and performance on the individual subtests of the phonological awareness test further, four stepwise linear regressions were carried out. (For a further discussion of this form of analysis see 5.9.1.) One of the subtests of the phonological awareness test was the dependent variable for each of the regressions (see Appendix 7). Univariate analysis (see section 5.10. and Appendix 4) had suggested that the scores on the individual subtests of the phonological awareness test were not normally distributed. The normal plots of the residuals and the scatter plots of standardised predicted values against standardised residuals indicated that only one of these only one of these regression analyses met the assumptions necessary for a linear regression to be carried out (see 5.9.1.). For the regression analysis in which subtest pa1 (acceptability judgements) was the dependent variable no independent variables were entered into the equation; no variable made a significant contribution to the variance of the dependent variable. The regression analyses in which subtests pa2 (phoneme identification) and pa3 (rime judgement) were the dependent variables did not meet the assumption of normal distribution, nor the assumption that there is no relationship between the variables. However, the regression analysis in which subtest pa4 (feature analysis) was the dependent variable did meet the necessary assumptions. Auditory memory was the only variable in the equation and accounted for a significant proportion of the variance in scores on the subtest pa4 (.22490) corrected to .20210 for the population as a whole.

5.14. PERFORMANCE OF SUBJECT 21 WHO HAD THE HIGHEST SCORES ON THE READING TEST (ST) AT 5 YEARS OLD.

Table 5.17: Performance of subject 21 at four years old

Subject	SX	pa1	pa2	pa3	pa4	PA total					
21	2	30	15	19	20	84					
Subject	EAT	BPVS	WIPPSI	AM	AD	FB	PL	AUD	MED	PED	EXP
21	58	50	99	12	18	2	1	1	1	0	1

These results are presented to support the discussion in section 7.9.

5.15. SUMMARY

- 25% of the variation in phonological awareness scores was accounted for by performance on the test of speech perception.

- The next most important variables affecting variation in the phonological awareness scores were performance on the vocabulary, and on the speech production, tests but these were not sufficiently significant to be included in the equation of the stepwise multiple regression.

- Children with high/low phonological awareness scores showed significant differences in means on the variables speech perception, auditory memory and vocabulary.

- Overall scores on the phonological awareness test were significantly correlated with scores on the variables speech perception and production, auditory memory and vocabulary.

- The phonological awareness test scores were highly correlated with three of the subtest scores (acceptability judgements, rime judgement and feature analysis) but not with the subtest phoneme identification (pa2).

- Scores on the subtests feature analysis (pa4) and acceptability judgements (pa1) showed a weakly significant correlation, as did feature analysis (pa4) and rime judgement (pa3).

- A significant proportion of the variance in performance on the phonological awareness subtest feature analysis (pa4) was related to scores on the auditory memory test (AM).

- Individual phonological awareness subtests showed different patterns of correlation with the independent variables further supporting the suggestion that these subtests assess different abilities.

- There was some evidence to support the hypothesis that final phonemes were harder for children to recognise/segment that onsets/initial phonemes.

- There was some weak evidence to support the detection/correction hierarchy of difficulty.

CHAPTER 6

Experiment 2

6.1. INTRODUCTION

The second phase of the investigation had two main aims;

- To build upon Experiment 1 in order to explore the nature of inter- and intra-subject change in phonological awareness over time.
- To investigate the potential offered by recent work on phonological memory to extend the findings of the original study.

6.2. CHANGE OVER TIME

6.2.1. Cross-sectional studies

The majority of studies of phonological awareness have been cross-sectional, looking at one age group of children over a relatively short testing period. Few of these studies have actually controlled for age, as the first experiment in this study did. However, some have studied a group of children from a restricted age band. For example, Chaney (1992) (see sections 2.3.4.5. & 3.5.1.5. for fuller discussion of this study) assessed the phonological awareness of 43 children aged 2;9-4;2 (mean age 3;8) with each child being seen over periods of between 3 and 9 weeks. Bowey and Patel (1988) (see section 2.3.4.5. for further description of this investigation) studied 60 children aged 5;6-7;0 (mean age 6;1) at a time when they were half way through their first year at school. The testing period lasted approximately 3 weeks. Carlisle and Normanbhoy (1993) (see section 2.3.4.4. for further discussion of this study) studied phonological and morphological awareness on 101 children aged 5;11-7;9 (mean age 6;9) who were in their first year at school. The testing only took one session. Whitworth and Zubrick (1983) (see section 1.3.3.2. for a more detailed description of the study) investigated 120 children aged 4;0-6;11 on a range of metalinguistic tasks including phoneme categorisation. Each child was tested for only one session.

In these studies the larger the subject group the wider the included age range appears to have been. Other investigations (e.g.. Kahmi and Koenig, 1985; Kahmi, Lee and Nelson, 1985; Bird and Bishop, 1992) have studied a wider age range of normally developing children because these subjects have been controls for phonologically disordered children. Smaller numbers of children have typically been involved in these studies.

For example, Bird and Bishop (1992) (see section 3.2.8. for a fuller discussion of this study) saw 14 control children aged 4;10-6;4 with a mean age of 5;8, and testing took place over 2 sessions. Kahmi, Lee and Nelson (1985) saw 15 age matched controls aged 3;0-6;0. No details of the length of the testing period are given. Warrick and Rubin (1992) (see section 2.3.3.7.) studied 15 age matched controls with a mean age of 5;2 who were tested for one session during one of the two years before school began.

One example of a large group study covering a wide age range is Dowker's (1989) study of the rhyming skills of 133 children aged 2;0-6;0 (see section 1.3.2.2. or a fuller description of this study). The children appear to have been seen over a relatively short time period. Kirtley, Bryant, MacLean and Bradley (1989) studied the ability of 88 children aged five (mean age 5;0), six (mean age 6;1) and seven (mean age 7;3) to identify onset units. Each child was tested over a short time period (see section 1.3.2.3. for further details).

Whilst studies such as that of Dowker (1989) and Kirtley et al (1989) investigate the abilities of children of differing ages, they obviously do not allow comparison of individual children's ability over time. The few longitudinal studies which have been done have generally explored the relationship between early phonological awareness and later reading skills (see for example, Bradley and Bryant, 1983; Naslund and Scheider, 1991; Magnusson and Naucler, 1993).

6.2.2. Longitudinal studies

In an influential study Bradley and Bryant (1983) (for further details see section 1.6.2.1.) investigated the phoneme segmentation skills of 118 four year old and 285 five year old children and found them to be strongly related to reading and spelling skills over 3 years later. This relationship held even when the effect of intellectual level and memory were controlled for. Unfortunately, the four and five year old children were assessed on different measures and the metaphonological assessments were not repeated thus preventing detailed study of the development of phonological awareness.

Similarly, in Naslund and Schneider's (1991) longitudinal study (see section 6.3.5. for further discussion of this investigation) different phonological awareness tasks were administered to the children at kindergarten, and in second grade. Despite the fact that the tests were 'intended to measure the same construct' (p383) such an experimental design makes analysis of change in task performance difficult.

Magnusson and Naucler (1993; Magnusson, 1991) carried out a longitudinal study of 39 normally developing children and 76 language disordered children matched for cognitive level, sex and age. Testing began at age 6;0 which is still the pre-school level in Sweden. The children were tested on metaphonological tasks including rhyming, identification and segmentation of phonemes and testing continued until the children had been at school for four years.

Magnusson and Naucler (1993; Magnusson, 1991) found that the rank order of test difficulty was maintained at all stages of testing with phoneme segmentation being the most difficult followed by phoneme identification and rime recognition. Whilst performance on all tasks increased with age Magnusson and Naucler argue that age is not the only variable influencing progress. Magnusson and Naucler found that, during the pre-school year, segmentation ability did not develop in the language disordered children. This was true even for those children who were having speech language therapy which, it could be argued, might assist the development of segmentation skills. However, these segmentation skills did improve in the normally developing children (who had had neither speech language therapy or reading instruction). Magnusson and Naucler noted that the metaphonological skills of both groups increased most rapidly during the first school year when the children were subject to intensive reading instruction.

Overall, Magnusson and Naucler (1993; Magnusson, 1991) found that performance on metaphonological tasks at age 6 was predictive of later metaphonological performance and that there was some evidence that children later identified as good readers were distinguished by higher levels of phonological awareness, short term memory and non-verbal intellect.

Howell (1989) retested 19 phonologically disordered children (mean age 5;2) and 21 normally developing children (mean age 5;3) (see section 3.5.2. for a fuller discussion of this study) around one year after they were first studied. She found that scores on the rhyming and phoneme segmentation tasks increased significantly with age although the relationship was not absolute; that is, some younger children had better phonological awareness skills than older children. Further, there was marked intra-subject variation with some children showing marked change and others failing to make progress.

However, Howell (1989) notes that there were some methodological difficulties. The time between first and second testing varied between subjects; some subjects had begun to attend school in the interim and some had not; some of the phonologically disordered children had had speech language therapy whilst others had not. Whilst there is contradictory evidence about the effect of different forms of speech language therapy on phonological awareness (see for example, Magnusson, 1991; Howell and Dean, 1994), control of such variables would have been helpful in interpreting the results.

6.2.3. Implications for Experiment 2

The importance of the study of developmental change in phonological awareness is clear. If there is a relationship between emerging metaphonological skills and either speech and language disorder or literacy difficulties, early identification of relevant children would be advantageous for the implementation of remedial programmes. Further, if the link between phonological awareness and literacy skills holds good then it might be possible to enhance reading ability, in all children, by means of early facilitation programmes.

Several examples of such facilitation programmes have been reported in the literature (see, for example, Bradley and Bryant, 1983; Lundberg, Frost and Petersen, 1988; Byrne and Fielding-Barnsley, 1991; Lie, 1991; and section 1.6.). Whatever the effect of such programmes, without robust evidence of the stability of phonological awareness over time, the argument for such intervention is weak. For example, if it can be shown that the subjects with the highest levels of phonological awareness at age four fail to maintain this position in relation to the cohort at age five, the potential role of a facilitation programme would be quite different; i. e. to maintain a position rather than to promote progress.

Therefore the second phase of this study was designed to explore the development of phonological awareness over time in individual subjects. The subjects who had been tested within a month of their fourth birthday were retested on the same metaphonological assessment within a month of their fifth birthday.

6.3 THE INFLUENCE OF PHONOLOGICAL MEMORY

The second aim of this experiment was to explore ways in which the methodology of the first experiment could be improved in order to allow a more accurate evaluation of the cause of variation in the dependent variable, phonological awareness.

It was considered that one way in which the methodology could be improved was in the area of assessment of auditory memory. The first study had adopted a sentence, rather than a digit, repetition test following criticism (i. e. Howell, 1989) of the relevance of the latter to metaphonological skills. It would seem sensible to assume that, in young children, the ability to remember phonological form would aid judgement about, or manipulation of, that sound structure. However, in the analysis of the results of the first investigation, auditory memory skills did not account for sufficient variation to be included in the regression equation. The recent literature concerning the working memory approach to the study of memory appeared to offer an alternative way of conceptualising (and therefore assessing) these abilities which might allow the contribution of auditory memory skills to be more accurately evaluated.

6.3.1. Phonological memory: Overview

The working memory approach assigns working memory an active role in complex cognitive tasks such as language processing. Working memory is involved in processing and storing information. Gathercole and Baddeley's (1993) model, for example, has three main components; the central executive, the phonological loop and the visuo-spatial sketch pad. The central executive controls the action and the transmission of information between the other two components of the working memory system and the visuo-spatial sketch pad is involved in processing information with visual or spatial dimensions. The phonological loop is able to process and maintain phonological information and consists of a phonological short-term store and a subvocal control process used for rehearsing and recoding information into phonological form. Gathercole and Baddeley suggest that phonological loop skills appear to be separable from more general processing capacities which may be more closely related to central executive functioning.

6.3.2. The development of phonological memory

Gathercole and Baddeley suggest that all three main components of working memory appear to be present in children of around four years old. At this age children appear to retain auditory information within the phonological loop and to use a rudimentary form of rehearsal. Subvocal rehearsal is reported to develop in the early school years and may be used as a strategy for recoding non-auditory material. There is some support for the suggestion that children as young as five years old may have the cognitive architecture necessary for recoding via subvocal articulation even though they may not use it spontaneously for non-auditory material (Gathercole and Baddeley, 1993).

It appears that whilst the phonological loop does contribute to young children's immediate memory for spoken material, the system operates in a relatively rudimentary fashion and may not involve sophisticated rehearsal processes of the kind used by older children and adults. This rudimentary form of rehearsal may be akin to an immediate echo of the phonological form. Gathercole and Baddeley (1993) argue that full strategic rehearsal of all linguistically codeable material emerges some years later, at around seven years of age.

This phonological recoding strategy is effective for regular words (grapheme-phoneme conversion). It is aided by context which allows candidates to be generated based on partial phonological recoding. (Phonological recoding uses letter-sound correspondences to identify words whose visual forms are not familiar.) Gathercole and Baddeley suggest that phonological memory skills are necessary for the development of a phonological recoding strategy. However, there seems to be no significant correlation between phonological memory and the rate at which the child establishes a sight vocabulary. This may be a consequence of the content of the tests used to measure reading - most of which have a high proportion of irregular words and thus require the child to access the lexicon rather than applying grapheme-phoneme conversion skills.

6.3.3. The relationship between phonological memory and vocabulary acquisition

Another strand of research has begun to highlight the contribution of phonological memory to vocabulary acquisition. The nature of the developmental association between vocabulary acquisition and phonological memory continues to be a live issue. Using a non word repetition task, Gathercole, Willis, Emslie and Baddeley (1991) assessed phonological memory and found evidence that accuracy of repetition in four, five and six year old children was sensitive to two independent factors; a phonological memory factor (non word length in terms of number of syllables) and a linguistic factor (word 'likeness'; the extent to which items conform to the phonotactic constraints of English). Gathercole, Willis, Emslie and Baddeley (1991) explain these results by suggesting that non word repetition involves temporary phonological storage which may be supported by either a specific lexical analogy or abstract phonological structures (or reference frames) generated from structurally similar vocabulary items (for example rimes). Such reference frames are argued by Gathercole, Willis, Emslie and Baddeley (1991) to be a central executive component of working memory rather than the phonological loop and to have the effect of reducing the demands placed on the phonological memory system during non word repetition.

Research into the relationship between phonological memory and vocabulary has also drawn on examples provided by children with developmental linguistic difficulties who have impaired word learning skills. Gathercole (1993) argues that a child needs to abstract and learn two types of information about each vocabulary item (conceptual attributes[1] and a phonological representation) before it can be considered to have been acquired. Gathercole investigated which aspect(s), conceptual, phonological or both, is/are impaired in children with word learning difficulties. She found that seven to nine year old language disordered children were poorer at repeating 3 - 4 syllable non words (a test of short term retention of phonological form) than two control groups (one matched on non-verbal skills; the other group younger and matched on verbal skills). The language disordered children performed at the level of four year old children, and the deficit in phonological memory was greater than the tested deficit in other linguistic skills.

Gathercole (1993) argues that these findings suggest that a deficiency in phonological working memory is one of the principal causes of word learning difficulties in children with impaired language development. Close links were also found between nonword repetition skills and vocabulary knowledge in children without developmental problems. Gathercole (1993) suggests that the findings indicate that language impaired children may represent the extreme tail of the normal distribution of phonological memory skills.

6.3.4. Other factors influencing non word repetition

However, the work of Gathercole and her colleagues has not gone unchallenged. Snowling, Chiat, and Hume (1991) argue that Gathercole and her colleagues use the concept of 'phonological memory' to cover an undifferentiated range of influences on non word repetition. Whilst agreeing that the efficiency of processes tapped by a nonword repetition task seems likely to be implicated in constraining a child's ability to learn new vocabulary items, they suggest that children may fail such a task for a variety of reasons including difficulties with perception, input phonology, storage of phonological information, segmentation and output phonology including assembly of articulatory patterns. For

[1] The meaning of the word (the conceptual attributes) is specified by the referents, context and grammatical class.

example, Snowling, Goulandris, Bowlby and Howell (1986) report a study (see section 6..3.5. for a fuller description of this study) from which they conclude that the performance of dyslexic children on a nonword repetition task is a result of their difficulty with segmentation.

Further, Snowling, Chiat, and Hume (1991) argue that performance on a non word repetition task may be affected by other factors relating to the target items, such as prosodic features; an unstressed syllable being more likely to be deleted than a stressed syllable. Gathercole, Willis and Baddeley (1991a) argue strenuously that they have not taken too broad a view of 'phonological memory' and, indeed, that they have reported several projects (for example, Gathercole, Willis and Baddeley, 1991b) which have investigated the contribution of other processing abilities such as segmentation difficulty and articulatory constraints (see 6.3.5. for a description of this study).

6.3.5. The relationship between phonological memory and phonological awareness.

Tasks designed to profile phonological memory, and tests which aim to assess phonological awareness both involve phonological processing. Phonological memory (short term memory ability) and phonological awareness (the ability to make judgements about, or to manipulate, sound structures of words) have both been implicated in the development of literacy. The question is whether these two types of task tap dissociable skills or whether phonological memory and phonological awareness arise from a common phonological substrate. The resolution of this question has implications for the way in which the relationship between phonological skills and reading development is characterised and, more particularly, for identifying the nature of working memory involvement in the acquisition of literacy.

One example of research in this area is the longitudinal study by Naslund and Schneider (1991) in which they followed 92 German children from kindergarten (mean age 6:1 years) to early elementary school. They argued that, as reading skills become more practised, memory capacity for what is read is enhanced due to the increased efficiency of text processing; and further, that efficiency of processing is likely to be related to the development of phonological awareness. Naslund and Schneider (1991) suggest that, during reading, the meaning of words and phrases is accessed from the reader's lexicon. Then the sequence of text is recoded phonologically for processing and retention in working memory. Arguing that tests of phonological awareness also require the subject to perform some recoding of cues, Naslund and Schneider (1991) hypothesise that levels of phonological awareness might therefore be expected to be evidenced by performance on a phonological recoding task and that a high level of phonological awareness might have positive effects on the development of phonological recoding skills needed for fluent reading.

Using tests of phoneme oddity and syllable segmentation with the kindergarten children; tests of error detection and phoneme manipulation with the elementary school children; and a word span test of working memory Naslund and Schneider (1991) found that the relationship between memory capacity and phonological awareness remained stable over time, and that memory capacity predicted performance on phonological awareness tasks both at kindergarten and 2nd grade level. The results indicated that the capacity to store and retain information continued to have a significant influence on phonological processing even during the second year of reading instruction. Naslund and Schneider (1991) conclude that the ability to perform phonological awareness tasks, such as recognition and manipulation of phonemes, is affected by limitations on memory capacity.

Gathercole and Baddeley (1993) review the literature and conclude that

- both types of phonological processing abilities (phonological awareness and phonological memory) appear to play a causal role in the acquisition of literacy skills, and
- both can be linked with the development of a phonological recoding strategy for reading and spelling.

It has been suggested that phonological memory and phonological awareness reflect a common phonological skills domain - both drawing upon the child's phonological representation of linguistic stimuli. This notion of commonality would account for a number of established empirical findings, for example;

- why phonological memory skills are related to accuracy and speed of producing words and phrases
- why children with poor reading ability are poor at both phonological awareness and phonological memory tasks
- provides a plausible account of why both phonological memory and phonological awareness are implicated in the development of a phonological recoding strategy in reading.

Direct investigation of phonological memory and phonological awareness however, have failed to reveal an equivalence relationship. There seems to be some degree of independence. For example, Bryant and Bradley (1983) found that there was a significant link between early phoneme detection scores and later reading even after scores for phonological memory had been taken into account. This suggests a degree of independence between rime awareness and phonological memory although Gathercole and Baddeley (1993) suggest that this finding might have been influenced by the nature of the reading test used.

Further support, for this hypothesised interrelationship between phonological processing skills, is provided by Gathercole, Willis and Baddeley (1991b) who looked more directly at the relationship between rime awareness (one test; a rime oddity task) and phonological memory (two tests; non word repetition and digit span) skills in four and five year old children. All three phonological measures were significantly inter-correlated although the two memory tests were more closely associated. The two phonological memory measures were significantly related to vocabulary knowledge at the ages of both four and five, and to reading achievement at five. However, rime awareness was not significantly associated with vocabulary knowledge at either age but was strongly associated with scores on one of the reading tests. Gathercole, Willis and Baddeley (1991b) argue that the findings indicate that although there appears to be a common phonological processing component underlying both phonological memory and phonological awareness, the tasks reflect separate cognitive skills which make differential contributions to reading and vocabulary development.

The complex nature of the developmental association between phonological memory and phonological awareness is illustrated by the study carried out by Snowling, Goulandris, Bowlby and Howell (1986) who suggested that the link between segmentation skills and memory could be attributed to a third shared process that is impaired; for example, accessing or activating phonological codes. They argued that there might be two alternatives; either that early perceptual problems could have hindered the ability of poor readers to set up phonological representation for words whose meaning they know, or that the absence of complete phonological representations would affect repetition if output phonology cannot be accessed.

Snowling and her colleagues (1986) studied 19 children with reading difficulties aged between 9;0 and 12;8 years (mean 10;9) with reading ages between 7;5 and 9;7 (mean 8;6) . These subjects were matched with 19 normal readers of similar age and intellectual level. During three experiments the children were asked to repeat high frequency words, low frequency words and non words under each of three noise conditions; no noise, low noise, high noise. As they failed to find a differential effect, on speech processing, for noise masking the authors concluded that the verbal memory deficits demonstrable in dyslexic children could not be accounted for by breakdown at the level of speech perception. Snowling et al (1986) present an alternative hypothesis; that it is phoneme segmentation difficulties which affect dyslexic children's performance on repetition tasks and further, that segmentation and repetition difficulties may indirectly affect ability to make use of phonological memory codes, leading to poor performance on tests of phonological memory.

Gathercole and Baddeley (1993) suggest that such evidence of the complexity of the relationship between phonological awareness, phonological memory and reading abilities highlights the need for distinct theories which link the three skills. Accounts which attribute such abilities to an undifferentiated 'phonological substrata' are unlikely to be adequate. Gathercole and Baddeley (1993) argue that there may well be a common phonological processing component of the type suggested by Shankweiler and Crain (1986) (which encompasses several phonological processing skills) but that 'phonological memory' and 'phonological awareness' have unique attributes which require theoretical explanation. Such a conclusion is supported by the theoretical evidence presented by Wagner, Torgesen, Laughon, Simmons and Rashotte (1994) of the distinct but interrelated nature of these components of phonological processing (see section 3.2.6. for further discussion of this study)

Gathercole and Baddeley (1993) argue, further, that whilst phonological memory and phonological awareness make a unique contribution, they also combine in promoting reading development. Awareness of sound structure enables the child to strip off phonemes from familiar words, and adequate phonological memory skills facilitate the learning of grapheme-phoneme rules which can be applied to the segmented phonemes.

In order to investigate the relationship between metaphonological awareness and phonological memory in the pre-literate children involved in Experiment 2, Gathercole, Willis, Baddeley and Emslie's (1994) test of non word repetition was employed.

The following sections report the methodology and results of the second experiment.

6.4. AIMS OF EXPERIMENT 2

- To build upon Experiment 1 in order to further explore the nature of inter- and intra-subject change in phonological awareness over time.
- To investigate the potential offered by recent work on phonological memory to extend the findings of the original study.

6.5. DESIGN

This phase of the investigation involved the retesting of the subject group from Experiment 1, on a battery of assessments, within a given time period. The subjects' performance was analysed using univariate, bivariate and multivariate statistical analyses. The time demands, on subjects, of the testing within Experiment 2 was limited as concerns had been raised by the Ethics Committee of Lothian Region Education Department about the number of testing session each child would undergo (see section 6.8.1. for a discussion about the implications of these constraints).

6.6. ETHICAL APPROVAL.

Ethical approval for the study was given by the Ethics Committee of Lothian Region Education Department and by the Ethics Committee of Queen Margaret College.

6.7. SUBJECTS

6.7.1. Contacting the subject group

One year after the first study it proved possible to contact and reassess 41 out of the original 46 children. The subjects who were not seen again were subjects 14, 17, 29, 32 and 46. This attrition occurred despite steps taken to avoid it. When the school staff, parents and children were thanked at the end of their participation in Experiment 1 they were reminded about the second phase of the study (see Appendix 1). At the beginning of the second phase of testing a letter was sent to each school and family (see Appendix 1) saying that the author would contact them/the school (depending on where the child was to be seen) to arrange suitable times to see the subjects.

6.7.2. Reasons for attrition

One parent (S14) replied saying that he would prefer that his child did not take part in the next study. Further information was sent in the hope of influencing this decision but no answer was received. One family appeared to be willing for their child (S29) to take part but could not be contacted to arrange a suitable time for testing. One family (S32) could not be contacted by phone and did not reply to follow up letters until after the appropriate testing time. One child (S17) was unwilling to come for testing when asked, despite sensitive preparation by his teacher. The mother of subject 46 felt unable to arrange a time for him to be retested either at home or within another setting. As this family had several ongoing problems with the health of a sibling, there was no option but to cancel retesting.

6.8. METHODOLOGY

All sessions took place within quiet rooms (either within the schools or at Queen Margaret College) where the children could concentrate and listen, and where a tape-recording of reasonable quality be made. One child (S13) was seen at home. All the children (with 1 exception, S 24) were seen within 4 weeks of their fifth birthday. Subject 24 was seen within 6 weeks. Each child was seen for one session which lasted approximately forty five minutes.

6.8.1. Changes to the assessment battery

Due to time constraints it was necessary to limit the number of assessments involved in the second experiment in order that each child was only seen for 1 (or at the most) 2 sessions (as opposed to the 4-5 sessions of the first investigation). In order to include the assessment of phonological memory (see section 6.3.5.), and as linguistic skills were not the main focus of the study, the decision was taken to omit the vocabulary test (BPVS) employed in the original study.

A further alteration to the test battery was made on the grounds that the statistics provided in the WIPPSI-R manual suggested that there was a high correlation between scores on the Block subtest and the overall non-verbal quotient. This relationship was calculated for the results from the first experiment and there was also a highly significant correlation for this group of subjects ($p<.001$) (see Appendix 6). Thus, in the smaller scale, second experiment non verbal cognitive skills (BL) were estimated using the Block subtest of the WIPPSI.

6.8.2. The assessment of phonological memory (PM)

In order to investigate the relationship between phonological awareness and phonological memory, the Children's Test of Non word Repetition (Gathercole, Willis, Baddeley and Emslie; 1994), was added to the test battery. This assessment comprises 40 non words divided into 4 equal sets containing 1, 2, 3, and four syllable words respectively (See Appendix 2 for score sheet.) The phoneme sequences within each word are phonotactically and prosodically legal in English.

The instructions used in the second experiment constituted an amendment to the test procedure as described by Gathercole, Willis, Baddeley and Emslie (1994) and were implemented following pilot trials in which children appeared rather bored by the test and on which their performance began to deteriorate due to loss of attention. In Experiment 2 the children were told that the experimenter was going to see if they could say some 'dinosaur' words. This appeared to capture the children's imagination. Several commented that the nonwords were names of dinosaurs and one child suggested that the experimenter had forgotten to say 'brontosaurus'.

The words were spoken by the experimenter as Gathercole, Willis, Baddeley and Emslie (1994) found that there were advantages due to the improved acoustic quality of a live presentation. The subjects' responses were recorded, but in the first instance the scoring was binary; a simple yes/no decision as to whether the word had been repeated correctly. The scoring took account (based on the EAT results) of habitual substitutions in an individual child's speech and, following the practice of Gathercole et al. (1994) did not score these as errors.

6.8.3. The assessment battery

Apart from the changes detailed in 6.8.1., the tests employed in Experiment 2 were identical to those used in Experiment 1.

The assessment battery comprised tests of

- Phonological awareness (PA)

  This assessment was designed for the experiment and comprised 4 subtests

  1. Subtest 1: acceptability judgement (pa1)
  2. Subtest 2: phoneme identification (pa2)
  3. Subtest 3: rime judgement (pa3)
  4. Subtest 4: feature analysis (pa4)

  See Table 4.1, and section 4.7 for further information about the format of these subtests and Appendix 2 for examples of the data collections sheets.

- Speech perception (AD) (Howell, 1989)
- Speech production (EAT) (The Edinburgh Articulation Test (Anthony, Bogle, Ingram and McIsaac, 1971))
- Non-verbal cognitive skills (BL) (The block subtest of the Wechsler PreSchool and Primary Test of Intelligence - Revised (Wechsler, 1990))
- Phonological memory (PM) (The Children's Test of Non word Repetition (Gathercole, Willis, Baddeley and Emslie; 1994))
- Auditory memory (AM) (Wechsler PreSchool and Primary Test of Intelligence - Revised (Wechsler, 1990)
- Literacy skills (ST) (The Aston Index (Newton and Thomson, 1976))

(See sections 4.7 to 4.10 for further details of these assessments).

6.8.4. Order of testing

The tests were always carried out in the same order (AD, ST, BL, EAT, AM, PM, pa1, pa4, pa3, pa2). As in Experiment 1, the order of testing was chosen on the basis of the investigator's clinical experience and confirmed by the pilot study and the experience of the first experiment. In some cases, when testing took place within the QMC clinic, a parent was present but as in the first stage of the study all sat at a distance, behind the child, and did not participate. In addition to the background information gathered in Experiment 1, a note was made of whether the child had begun to attend school or not since last testing.

6.9. RESULTS: INTRODUCTION

A spreadsheet with the full data set is in Appendix 8. Seven of the explanatory variables were in the form of categorical data; sex (SX), history of ear infections (AUD), place in family (PL), family background (FB), level of parental education (MED, PED), attendance at school (SCH) and dummy variables were created to code these.

As for Experiment 1, the data analysis is presented in three sections which cover univariate, bivariate and multivariate analyses (see Appendices 9, 10/11 and 12 respectively). The data was collated using an Excel spread sheet and imported into SPSS for analysis. Texts used to inform the data analysis included Altman (1991), Cramer (1994), Erickson and Nosanchuk (1992), Everitt and Hay (1992), Foster (1993) and Norusis (1993). Overall, a 95% confidence interval was adopted, with a cut off level for statistical significance of 0.05.

6.10. RESULTS: UNIVARIATE ANALYSIS

6.10.1. Categorical data: distribution

This information is summarised in Table 6.1.

Table 6.1: Summary of background information for subjects in Experiment 2

	YES	NO	N=
History of ear infections (AUD)	16	20	36[2]
Older siblings (PL)	17	24	41
Mother with full time post school education (MED)	24	17	41
Father with full time post school education (PED)	25	16	41
Bilingual	0	41	41
Literate	1	40	41
At school	21	20	41

[2]As described in the analysis of Experiment 1 (see section 5.7.1.). not all questionaires distributed were returned and some were spoiled.

Sex

There were 18 boys and 23 girls in the second study.

History of ear/hearing problems (AUD)

16 subjects in the second study (on the basis of the questionnaires filled in by parents before the first experiment) had a history of ear infections and 20 did not.

Family background (FB)

18 of the subjects came from families calculated to be in social grouping FB1, 17 in FB2 and 6 from FB3. The latter group was so small it was not included in the bivariate analyses.

Level of parental education (MED, PED)

24 of the children had mothers who had had full time education post school and 17 did not. 25 of the children had fathers who had been in full time education post school,. and 16 did not. The mean age for mothers to leave full time education was 19 and for fathers was 22.

Place (PL)

17 of the children (including one set of twins; Subjects 25 and 26) had no older siblings and 24 did.

School (SCH)

21 of children had begun to attend school between the first and second experiment and 20 were still in pre-school placements.

Bilingualism

As detailed in section 5.7.1. no child was bilingual; that is, spoke or understood a language other than English. Of the five children whose parents noted that their child might have had minimal exposure to another language, four were involved in the second testing (S 4, 15, 39 and 45).

Literacy

Only one subject (S 21) showed substantial evidence of word recognition; reading ten items on the Schonnell Reading Test. Two other subjects (S 2 and 10) were able to recognise one word.

6.10.2. Interval data: distribution

Table 6.2 summarises the scores for the group on each test yielding interval data. For box, stem and leaf plots of the distribution of each measure see Appendix 9.

On three tests (those of speech perception and production (AD, EAT) and phonological awareness (PA)) some subjects reached ceiling. On the EAT three subjects (S 4, 22, 25) reached ceiling (68) and two (S 29, 36) scored 67. On the PA

Table 6.2: Numerical summary of raw data from tests of phonological awareness (PA), speech production (EAT), non-verbal cognition (BL), speech perception (AD), phonological memory (PM) and auditory memory (AM).

Test	Mean	95% Confidence Interval	Median	Variance	Std deviation	Min	Max
PA	85.27	82.01, 88.53	88	106.70	10.33	61	100
EAT	58.39	55.88, 60.89	61	62.84	7.93	40	68
BL	19.15	17.22, 21.07	20	37.33	6.11	5	32
PM	24.51	22.11, 26.92	27	58.11	7.62	2	38
AD	17.90	17.30, 18.50	18	3.59	1.89	13	20
AM	20.02	18.31, 21.74	21	29.57	5.44	8	29

one subject (S 4) scored at a ceiling level of 100, one scored 99 (S 22) and two 98 (S 25 and 40). However, on the AD 9 subjects (S 2, 12, 13, 20, 25, 32, 34, 36, 37) scored at ceiling (20) a further seven subjects scored 19 and 13 scored 18. Thus, distribution of the scores on these tests was weighted toward the higher scores. To ensure that the data met the criteria for statistical analysis as well as possible (Everitt and Hay, 1992; Cramer, 1994) it was transformed to log scores.

6.10.2.1. Outliers

No one subject consistently scored outside the range of the distribution on all tests (see Appendix 8 for full data set and Appendix 9 for information about distribution). On the test of speech perception (AD) subjects 9 and 24 were outriders with low scores. On the test of nonverbal cognition (BL) subject 35 was a high outlier and subjects 8 and 20 low outliers. On the phonological memory test (PM) subjects 8 and 9 were low outliers. Although subject 8 was among the 5 lowest scorers for three other tests (EAT, AM and PA) and subject 24 was among the 5 lowest on the scorers on the EAT and AM they were not outliers on these tests.

These subjects (who tended to perform as outliers) were not removed from the analyses for two reasons. First, the same subject did not constitute an outlier on more than two tests, and second, it was considered that valuable data would be lost by not taking account of these subjects' performance. A log transformation of the data was carried out before bivariate and multivariate analysis to further reduce the effect of extreme values (Cramer, 1994).

6.11. RESULTS: BIVARIATE ANALYSIS

6.11.1. Differences between means

The data was analysed to investigate whether there was a significant difference on the variables phonological awareness (PA), speech production (EAT), speech perception (AD), auditory memory (AM), phonological memory (PM) and non-verbal cognition (BL) for groups of subjects who

- were boys/girls (SX),
- came from family backgrounds 1/2 (FB)
- had mothers who did/did not have post-school education (MED)
- had fathers who did/did not have post-school education (PED)
- did/did not have older siblings (PL)
- did/did not have a history of ear infections (AUD)
- were/were not attending school

One way Analyses of Variance were carried out on the transformed data (for the full analyses see Appendix 10). For a discussion of the distribution of the scores on individual variables see section 6.10.2.. The assumption that the groups had equal variances was tested using Levene's Test for Homogeneity of Variance. Assumptions that the variances were equal could not be made for the following comparisons:-

Table 6.3: Variables which did not have equal variances

	SX	PED	MED	FB	AUD	SCH
BL	*					
EAT	*	*	*	*		*
AD		*	*		*	
PA		*	*	*		
PM		*	*			*

A 95% confidence interval was adopted. An F probability of less than 0.05 was taken to indicate a significant difference between groups (Altman, 1991). Table 6.4 summarises the significant differences that were found.

Table 6.4: Significant differences between means for groups with differing levels of maternal (MED) and paternal (PED) education, and with/without older siblings (PL)

	AM
PL	.0435
MED	.0245
PED	.0022

However, there were some significant differences between means for groups which did not meet equality of variance assumption. As the ANOVA is a robust test which does not always require all assumptions to be met, it is worth noting these differences (see Table 6.5).

Table 6.5: Significant differences between means for groups that did not meet the equality of variance assumption

	SEX	PED	MED	FB
EAT	.0100	.0256	.0700	
AD		.0128	.0491	
PA		.0017	.0276	.0156
PM		.0070	.0189	

6.11.2. Differences between means for groups with high/low phonological awareness

To examine the difference between the subjects with high, and those with low, phonological awareness the subject group was divided into two subgroups comprising the

15 subjects with the highest phonological awareness and the 15 with the lowest (as measured on the test of phonological awareness).

As there were relatively small numbers of subjects in each group the decision was made to carry out a series of independent t tests to determine whether the means of the high and low phonological awareness groups differed with regard to each of the independent variables. Twelve independent t tests were carried out (see Appendix 10) The equality of the variances in the two samples was calculated using Levene's Test. A 95% confidence level and a cut off level for statistical significance of 0.05 were adopted. Table 6.6 summarises the significant differences between means found.

Table 6.6: The significance of the differences between means on the variables auditory memory (AM), nonverbal cognition (BL), speech production (EAT), phonological memory (PM) family background (FB) and level of parental education (MED, PED) for the groups of high and low scorers on the Phonological Awareness Test (PA).

	AM	BL	EAT	PM	FB	MED	PED
PA	.002	.012	.024	.019	.01	.025	.02

6.11.3. Correlation Coefficients: Interval Data

The extent to which any of the variables measured on interval scales correlated was calculated using the parametric measure Pearson's product moment correlation coefficient. (Transformed data was used in all correlations.) The full results are represented in a correlation matrix in Appendix 11. Table 6.7 summarises the significant correlations.

Table 6.7: Significant intercorrelations between phonological awareness (PA), speech perception (AD), speech production (EAT), auditory memory (AM), phonological memory (PM) and nonverbal cognition (BL).

	PA	AD	AM	PM
AD	.3300 p<.035			
AM	.4977 p<.001	.4390 p<.004		
PM	.6345 p<.001	.5818 p<.001	.5021 p<.001	
EAT	.4508 p<.003			.3164 p<.044
BL	.4605 p<.002		.5697 p<.001	.3670 p<.018

6.11.4. Correlation coefficients: categorical data

However, not all the variables are measured by interval scales (for example sex (SX), family background (FB), maternal education (MED), paternal education (PED), presence of older siblings (PL) attendance at school (SCH)). These constitute categorical data and are included in the correlational analysis by using Spearman's rank order correlation coefficient. The resulting matrix is presented in Appendix 11. The significant correlations are presented in Table 6.8.

Table 6.8: Significant intercorrelations between speech production (EAT), auditory memory (AM), phonological memory (PM), sex (SX), family background (FB), maternal education (MED), paternal education (PED), attendance at school (SCH) and presence of older siblings (PL).

	PA	AD	AM	PM	EAT	FB	MED
FB	-.4438 p<.004		-.3864 p<.013	-.4711 p<.002			
MED			.3126 p<.047			-.6477 p<.001	
PED	.4869 p<.001	.3577 p<.022	.4386 p<.004	.4660 p<.002	.3117 p<.047	-.7071 p<.001	.5446 p<.001
PL			-.3210 p<.041				
SCH						.3529 p<.024	-.3261 p<.037
SX					.4294 p<.005		

6.11.5. Correlation between memory tests

To estimate the extent to which the test of auditory memory (AM) employed in the original study measured the same ability as the phonological memory test (PM) introduced in the second experiment the AM and PM scores from the second experiment were correlated using the Pearsons Product Moment Correlation Coefficient. There was a significant correlation at the level of $p<.001$ (see Appendix 11).

6.12. RESULTS: MULTIVARIATE ANALYSIS

(For a general introduction see sections 5.91)

As can be seen from Figure 3 (Appendix 12; a scatter plot of standardised predicted values against the standardised residuals) the plot of the residuals shows the points evenly scattered at all X values with no evidence of any relationship. Figure 4 (Appendix 12) indicates that, whilst the variable points do not cluster in an absolutely straight line, nevertheless, there is no substantial evidence to suggest that the validity of a linear regression would be in question.

A multiple regression (stepwise) analysis applied to the transformed data indicated that the independent variables account for .72389 (Multiple R) percent of the variation in scores on the phonological awareness (PA) test (see Appendix 12 for full analysis). The significance of the F statistic ($p<.001$) allows the assumption that there is a linear relationship between the predictor and dependent variables; and thus that the regression equation allows the prediction of the dependent variable at a level greater than chance. That is, the predictor variables are not inter-dependent.

The variables included in the equation were phonological memory (PM), speech production (EAT) and nonverbal cognitive skills (BL) and the R squared of .52401 suggested that just over half the variation in the dependent variable was accounted for by the variables in the equation. This figure was corrected (Adjusted R Squared) to .47939 for the population as a whole. The Beta values indicate the relative importance of the variables in the equation; PM (.436860), EAT (.298117) and BL (.273390).

The presence of colinearity (i. e. when there is a high correlation between the independent variables) can be detected by examining the colinearity diagnostics such as tolerance (Norusis, 1993). Tolerance is the amount of the variation explained by one independent variable and not explained by the other independent variables in the model. A commonly used cut-off point for tolerance is 0.1. The tolerances of the variables included in the final equation (phonological memory, speech production and nonverbal cognition) are higher than this cut-off point and thus colinearity is low.

6.13. UNIVARIATE ANALYSIS OF SCORES ON THE INDIVIDUAL SUBTESTS OF THE PHONOLOGICAL AWARENESS TEST (PA).

Table 6.9 summarises the distribution of the scores on each of the subtests making up the test of phonological awareness (PA). Appendix 9 provides stem and leaf plots and additional data. A proportion of subjects reached ceiling on some subtests particularly pa1 (acceptability judgements) and pa4 (feature analysis). The criterion level for passing the phonological awareness subtests was calculated using the binomial distribution. (See section 5.10 for further detail about this calculation)

Table 6.9: Numerical summary of raw data from the subtests of the Phonological Awareness Test (PA).

	Test	Mean	95% Confidence Interval	Median	Variance	Std dev.	Min	Max	% Pass Rate
Pa1	**Acceptability. judgements***	29.10	28.19, 30.00	30	8.24	2.87	16	30	95.12
Pa2	**Phoneme identification**	22.24	20.50, 23.99	23	30.69	5.54	12	30	68.29
Pa3	**Rime judgement**	16.49	15.46, 17.51	17	10.51	3.24	9	20	75.61
Pa4	**Feature analysis**	17.41	16.44, 18.39	19	9.49	3.08	10	20	78

* Criterion pass rate calculated for acceptability judgements only (see text).

The critbinom formula (Excel) calculates the smallest integer for which the binomial distribution is greater or equal to a criterion value (alpha). In this analysis alpha was taken as 0.99 resulting in a significance level of 1%. That is, a child would be highly unlikely to have obtained such a score (and therefore deemed to have phonological awareness) by chance.

6.13.1. Pa1: Acceptability judgements

This proved the easiest of the tests with 95.1% of the four year old subject group reaching criterion (a score of 19). The total subtest score was made up from detection and correction scores with the percentage of correct answers on the detection task (out of the total number of items) being 98.8% whilst the total number of correct items on the correction task was 95.6%. (The numbers cannot be compared directly as there were twice as many opportunities to make judgements as to make corrections.) (See Appendix 9.)

6.13.1.1. Types of explanation

As in Experiment 1 the children were also asked to provide an explanation for their detection of error. These explanations were transcribed and then analysed into the five categories defined in section 5.10.12. (See Appendix 9 for the full data set.) The categories were non-specific: unrelated; non-specific: speech related; meaning centred; word centred and segment centred.[3]

6.13.1.2. Analysis

Three subjects (S 6, 11 and 12) produced no explanations. The number of subjects utilising each level of explanation is shown in Table 6.10.

Table 6.10: Number of subjects utilising each level of explanation

Type	Non-specific: unrel	Non-specific: sp rel	Meaning centred	Word Centred	Segment centred
No of subjects	10	4	10	36	18

[3]In these examples, as in Appendix 9, the following notation is used; '+' = the correct pronunciation produced by the tape recorded speaker; 'x' = the mispronunciation as made by the tape recorded speaker; '++' = the correct pronunciation correctly reproduced by the child; '+-' = the correct pronunciation incorrectly reproduced by the child; 'x+' = the mispronunciation correctly reproduced by the child; 'x-' = the mispronunciation correctly reproduced by the child..

As can be inferred from Table 6.10 some subjects produced several different types of explanation (see Table 6.11)

Table 6.11: Number of levels of explanation used

No of types of explanation	0	1	2	3	4	5
No of subjects	3	12	15	10	1	0

No subjects produced all five types of explanation and it was most common for subjects to use 1-3 types. One subject (S 1) used four types of explanation. The commonest single category used was word centred explanations (11 subjects). However, different subjects utilised different combinations of types of explanation.

In the second experiment 6 subjects (1, 13, 16, 21, 27, 33) commented on the fact that there was a mismatch between the speaker's performance on each pair of items (i. e. if on the first pass through the pictures the speaker had mispronounced the stimulus item, it was correctly produced the second time). Only subjects 20 and 43 failed to produce any word or segment centred explanations.

6.13.2. Pa2: Phoneme identification

This subtest was the most difficult for the five year old children with 68.29% reaching criterion (a score of 19). 11 children (Subjects 5, 6, 8, 13, 14, 22, 33, 34, 35, 41, 42) adopted the strategy of replying to all 20 (or 19[4]) items with the same answer; 10 choosing to reply 'yes' to all questions and 1 'no'. The performance of the remaining thirty children was analysed for trends indicating complexity of task (see Appendix 9 for full data set). Table 6.12 summarises the findings

[4] Two children produced one alternate answer.

Table 6.12: Percentages of stop and fricative phonemes correctly identified in different syllable contexts

	T /15	D /15	S /8	F /7	C(s)vc/ /4	C(f)vc /4	Cvc /8	cvC /7
sum	316	420			111	110		
%	70.22	93.33			92.5	91.66		
sum			163	153			221	90
%			67.92	72.86			92	42.86

KEY
T = target item D = distracter
F/f = fricative S/s = stop
Cvc = syllable initial position cvC = syllable final position
/x = total number of items

The children were more likely to judge the distracter items (93.3% correct) correctly than they were the target items (70.2% correct). Initial phonemes were equally easy to judge whether they were stops or fricatives. The comparisons between initial and final phonemes, and between initial and final stops and fricatives were complicated by the fact that (due to constraints of overall phonological awareness (PA) test construction) the subtest comprised 3 fricatives in syllable final position, but 4 stops in the same context. However, Table 6.12 gives percentage analyses which suggest that fricatives were marginally easier to identify than stops (overall syllable context) whilst initial phonemes/onsets were markedly easier for these subjects to identify than phonemes in syllable final position.

A t test for independent samples was carried out to determine whether or not admission to school affected performance on subtest pa2. There was no significant difference (see Appendix 10)

6.13.3. Pa3: Rime judgement

This test was the second hardest with 75.6% of the children reaching criterion (a score of 14). The test items were divided into word (e.g. 'head') and non word (e.g. 'med') rhymes with the target 'Ed' and word (e.g. 'fat') and non word (e.g. 'wat') distracters.

Overall, there was little difference in performance on the word and non word items with a total of 332 correct answers for word items (target and distracter) with 326 correct answers for non word items. (Total possible correct items = 820). (See Appendix 9)

6.13.4. Pa4: Feature analysis

78% of children reached criterion (a score of 14).

6.14. BIVARIATE ANALYSES OF SCORES FROM THE INDIVIDUAL SUBTESTS OF THE PHONOLOGICAL AWARENESS TEST.

6.14.1. Correlations between individual subtests of the Test of Phonological Awareness (PA)

Intercorrelations between the transformed data from the phonological awareness subtests and the overall phonological awareness scores were calculated using Spearman's correlation coefficient. (See Appendix 11 for full analysis.) The significant correlations are presented in Table 6.13.

Table 6.13: Significant intercorrelations between overall Phonological Awareness Test scores and performance on individual subtests.

	PA	Pa1	Pa2
Pa1	.4473 $p<.003$		
Pa2	.8680 $p<.001$		
Pa3	.7437 $p<.001$	.4600 $p<.002$	.5844 $p<.001$
Pa4	.3804 $p<.014$		

6.14.2. Correlations between subtests of the Phonological Awareness Test (PA) and other variables.

The transformed data from the individual phonological awareness subtests and all other variables were analysed using the Spearman correlation coefficient (see Appendix 11 for full analysis). Table 6.14 summarises the significant correlations.

Table 6.14: Significant intercorrelations between performance on phonological awareness subtests and measures of speech production (EAT), auditory memory (AM), phonological memory (PM), family background (FB), parental education (MED, PED), nonverbal cognition (BL), history of ear infections (AUD) and sex (SX).

	Pa1	Pa2	Pa3	Pa4
AM		.3874 p<.012	.3207 p<.041	.3842 p<.013
PM		.3267 p<.037	.4705 p<.002	.3626 p<.020
EAT	.3209 p<.041	.3711 p<.017	.4422 p<.004	
BL		(.3000) (p<.057)		
FB		(-.3000) (p<.057)	-.4310 p<.005	-.4451 p<.004
MED			.3189 p<.042	
PED		.4253 p<.006		.3501 p<.025
SX		.2864 p<.070		

6.15. MULTIVARIATE ANALYSES OF VARIABLES WHICH CONTRIBUTE TO VARIATION IN PERFORMANCE ON THE INDIVIDUAL SUBTESTS OF THE PHONOLOGICAL AWARENESS TEST AT FIVE YEARS OLD.

To investigate the relationship between the independent variables and performance on the individual subtests of the phonological awareness test further, four stepwise linear regressions were carried out. (For a further discussion of this form of analysis see 5.9.1.) One of the subtests of the phonological awareness test was the dependent variable for each of the regressions (see Appendix 12). Univariate analyses (see sections 6.10. and Appendix 9) had suggested that the scores on the individual subtests were not normally distributed. The normal plots of the residuals and the scatter plots of standardised predicted values against standardised residuals indicated that only one of the regressions met the assumptions necessary for a linear regression to be carried out. The regression analyses in which subtests pa1 (acceptability judgements), pa2 (phoneme identification) and pa4 (feature analysis) were the dependent variables did not meet the assumption of normal distribution, and/or the assumption that there is no relationship between the variables. However, the regression analysis in which subtest pa3 (rime judgement) was the dependent variable did meet the necessary assumptions. The variables speech production (EAT), acceptability judgements (pa1), phoneme identification (pa2) and family background (FB) accounted for a significant proportion of the variance in scores on the subtest pa3 (.65868) corrected to .61463 for the population as a whole.

6.16. CHANGE OVER TIME: A COMPARISON OF RESULTS FROM EXPERIMENT 1 AND EXPERIMENT 2.

T tests for paired samples were carried out to estimate change over time on the measured variables. (See Appendix 13) There was a significant difference between means for the following variables (Table 6.15);

Table 6.15: Change over time in assessed variables

Variable	significance level
AD	p<.001
AM	p<.001
BL	p<.001
EAT	p<.002
PA	p<.001

The degree of significant correlation between the variable phonological awareness and the other variables comprising interval data, for the first and second testing, is shown in Table 6.16. (See sections 5.8.3. & 6.11.3.)

Table 6.16: Correlates of phonological awareness (PA)

Variable	Experiment 1	Experiment 2
AD	p<.001	p<.035
AM	p<.005	p<.001
PM	p<.007	p<.001
EAT	p<.002	p<.003
WIPPSI/BL		p<.002

In the analysis of Experiment 1 the only variable comprising categorical data which correlated with PA was MED (p<.059). However, in the analysis of the second experiment PA correlated with FB (p<.004) and PED (p<.001).

6.17. CHANGE OVER TIME: A COMPARISON OF PERFORMANCE ON INDIVIDUAL SUBTESTS OF THE PHONOLOGICAL AWARENESS TEST

6.17.1. Acceptability Judgements (pa1)

Table 6.17 summarises the changes in distribution and success on subtest pa1 between the first and second testing. (See sections 5.10 & 6.13. for results from individual experiments)

Table 6.17: Change in Subtest pa1: acceptability judgements*

	Mean	95% Confidence Interval	Median	Min	Max	% Pass Rate
Experiment 1	26.78	25.39, 28.17	28	10	30	93.48
Experiment 2	29.10	28.19, 30.00	30	16	30	95.12

* Criterion pass rate calculated for acceptability judgements only (see section 6.13).

Performance on subtest pa1 was significantly different between the children at four and at five years old ($p<.001$). (See Appendix 13) Subtest pa1 proved the least difficult subtest for both four and five year old children, as evidenced by the percentage pass rate.

Table 6.18 summarises the changes in detection and correction scores, and Tables 6.19 and 6.20 the development in ability to provide explanations. (See sections 5.10.1. & 6.13. for results from individual experiments)

Table 6.18: Percentage correct scores on the detection and correction sections of pa1: acceptability judgements

	Detection	Correction
Experiment 1	92.61	82.83
Experiment 2	98.78	95.61

Table 6.19: Number of subjects providing each type of explanation during pa1: acceptability judgements.

Type	Non-specific: unrel	Non-specific: sp rel	Meaning centred	Word Centred	Segment centred
Experiment 1	15	12	8	25	11
Experiment 2	10	4	10	36	18

Table 6.20: Number of subjects utilising different types of explanations during pa1: acceptability judgements

No of types of explanation	0	1	2	3	4	5
Experiment 1	6	16	18	5	1	0
Experiment 2	3	12	15	10	1	0

6.17.2. Phoneme identification (pa2)

Table 6.21 details the changes in distribution and success on subtest pa2 on first and second testing.

Table 6.21: Change in subtest pa2: phoneme identification

	Mean	95% Confidence Interval	Median	Min	Max	% Pass Rate
Experiment 1	15.59	14.95, 16.24	15	11	25	4.35
Experiment 2	22.24	20.50, 23.99	23	12	30	68.29

Performance of the children at four and at five years old, on subtest pa2, was significantly different ($p<.001$). (See Appendix 13) Subtest pa2 was the most difficult subtest for both four and five year old children as evidenced by the percentage pass rate.

The changes in number of subjects being able to identify different phonemes, and phonemes in different contexts, are documented in Table 6.22.

Table 6.22: Percentage change in correct answers on subtest pa2: phoneme identification

	T /15	D /15	S /8	F /7	C(s)vc /4	C(f)vc /4	Cvc /8	cvC /7
Experiment 1	53.33	93.33	47.92	52.38	62.5	75	68.75	35.71
Experiment 2	70.22	93.33	67.92	72.86	95.5	91.66	92	42.86

6.17.3. Rime judgement (pa3)

Table 6.23 summarises the change in distribution and success rates on subtest Pa3, on first and second testing. (See sections 5.10 & 6.13. for results from individual experiments)

Table 6.23: Change in subtest pa3: rime judgement

	Mean	95% Confidence Interval	Median	Min	Max	% Pass Rate
Experiment 1	11.74	10.87, 12.61	10	8	19	19.57
Experiment 2	16.49	15.46, 17.51	17	9	20	75.61

There was a significant difference in performance between first and second testing ($p<.001$). (See Appendix 13). Subtest pa3 was the third most difficult subtest for both four and five year old children as evidenced by the percentage pass rate.

6.17.4. Feature analysis (pa4)

Table 6.24 summarises the change in distribution and success rates on subtest pa4, on first and second testing. (See sections 5.10 & 6.13. for results from individual experiments)

Table 6.24: Change in subtest pa4: feature analysis

	Mean	95% Confidence Interval	Median	Min	Max	% Pass Rate
Experiment 1	16.09	15.08, 17.09	16.50	8	20	65.22
Experiment 2	17.41	16.44, 18.39	19	10	20	78

There was no significant change in scores on subtest pa4 between first and second testing. (See Appendix 13) Six subjects showed a drop of 3 or more points on the second testing of subtest pa4 (Subjects 5, 9, 13, 21, 25, 39) . The average drop was 5.58 and the range 3 - 8. There was evidence of slight downward fluctuation in the performance of seven other subjects (S 2, 10, 15, 19, 30, 36). However, 10 subjects who reached ceiling (a score of 20 or 19) on first testing showed no subsequent drop (3, 4, 10, 11, 12, 18, 23, 24, 42, 44). The remaining nineteen subjects showed gains in scores on this test. Subtest pa4 was the second easiest PA subtest for both four and five year old children as evidenced by the percentage pass rate.

6.18. BIVARIATE ANALYSES OF CHANGE OVER TIME IN SCORES ON THE PHONOLOGICAL AWARENESS TEST.

The relationship between performance on the phonological awareness test at four and at five years old was calculated using Pearsons product moment correlation coefficient. The relationship was significant at the level p<.001 (see Appendix 13).

The relationship between scores on the independent variables tested at 4 years old and performance on the phonological awareness test at five years old was first explored by calculating the correlations between these variables (see Appendix 13). Table 6.25 summarises the significant correlations for the interval data (Pearsons product moment correlation coefficients) and Table 6.26 summarises the significant correlations for the categorical data (Spearmans rank order correlation coefficients).

Table 6.25: Significant correlations between performance on the independent variables tested at four years old and phonological awareness test (PA) scores at 5 years old: interval data.

	Speech Percept. (AD)	Aud Mem. (AM)	Vocab. (BPVS)	Speech Prod. (EAT)	Non-verbal cognition (WIPPSI)	Phonol. Aware. (PA)	Accept. Judgem. (pa1)	Feat. Ana. (pa4)
PA at 5;0 yrs	.3914	.5397	.5809	.4559	.4577	.5708	.4905	.4385
	p=<.011	p=<.001	p=<.001	p=<.003	p=<.003	p=<.001	p=<.001	p=<.026

Table 6.26: Significant correlations between performance on the independent variables tested at four years old and phonological awareness test (PA) scores at 5 years old: categorical data.

	Paternal education (PED)	Maternal education (MED)	Family Background (FB)
PA at 5;0 yrs	.4869	.3249	-.4438
	p=<.001	p=<. 038	p=<.004

6.19 MULTIVARIATE ANALYSES OF CHANGE IN THE RELATIONSHIP BETWEEN PHONOLOGICAL AWARENESS AT FIVE YEARS OLD AND OTHER VARIABLES TESTED AT FOUR YEARS OLD.

A stepwise multiple regression analysis was carried out, on transformed data (see 6.10.2.1.), to evaluate which of the variables tested at four years old was related to performance on the phonological awareness test at five.

Figure 5, Appendix 13, is a scatter plot of standardised predicted values against standardised residuals and indicates that there is no relationship between the variables. Figure 6, Appendix 13, indicates that while the variables do not cluster in an absolutely straight line, nevertheless there is no substantial evidence to suggest that the validity of a linear regression would be in question. The F statistic ($p<.001$) allows the assumption that there is a linear relationship between the predictor varables and the dependent variable at a level greater than chance.

The variables included in the equation are phonological awareness at four (PA), vocabulary (BPVS) skills at four, and paternal education (PED) (see Appendix 13). The Beta values indicate the relative importance of the variables in the equation; PA (.472329), PED (.375777), BPVS (.270421). The tolerance of the variables included in the equation are higher than the cut-off point of 0.1 (Norusis, 1993) and colinearity is low (see 6.12. for a further discussion of tolerance).

The variables in the equation together account for .62754 of the variation in the dependent variable, phonological awareness at five years old, corrected to .59262 for the population as a whole.

6.20. PERFORMANCE OF CHILDREN FROM FAMILY BACKGROUND (FB) 3

Table 6.27: The mean scores of subjects from FB 3, compared with the performance of the whole subject group, on first and second testing

	EXPERIMENT	ONE		EXPERIMENT	TWO
	subjects from FB 3	all subjects		subjects from FB3	all subjects
PA	69.167	70.39 (67.92,72.86)		79	85.27 (82.01,88.53)
EAT	50	54.65 52.18,57.11)		51.5	58.39 (55.88,60.89)
BPVS	34.167	40.15 (36.9,43.41)			
WIPPSI/BL	79.167	89.26 (82.36,96.16)		18.67	19.15 (17.22,21.07)
AM	11.33	13.85 (12.5,15.2)		15.33	20.02 18.31,21.74)
AD	15	16.43 (15.74,17.12)		16.5	17.90 (17.30,18.50)
PM				17.67	24.51 22.11,26.92)

6.21. MULTIVARIATE ANALYSIS OF THE CHANGE IN THE RELATIONSHIP BETWEEN PERFORMANCE ON INDIVIDUAL SUBTESTS OF THE PHONOLOGICAL AWARENESS TEST, AT FIVE YEARS OLD, AND OTHER VARIABLES TESTED AT FOUR YEARS OLD.

To investigate the relationship between the independent variables tested at four years old and performance on the individual subtests of the phonological awareness test at five years old, four stepwise linear regressions were carried out. (For a further discussion of this form of analysis see 5.9.1.) One of the subtests of the phonological awareness test was the dependent variable for each of the regressions (see Appendix 13). Univariate analyses (see sections 6.10. and Appendix 9) had suggested that the scores on the individual subtests were not normally distributed. The normal plots of the residuals and the scatter plots of standardised predicted values against standardised residuals indicated that only one of the regressions met the assumptions necessary for a linear regression to be carried out. The regression analyses in which subtests pa1 (acceptability judgements), pa2 (phoneme identification) and pa4 (feature analysis) were the dependent variables did not meet the assumption of normal distribution, and/or the assumption that there is no relationship between the variables. However, the regression analysis in which subtest pa3 (rime judgement) was the dependent variable did meet the necessary assumptions. The variables in the equation were vocabulary skills at four years old and family background, accounting for a significant proportion of the variance in scores on the subtest pa3 (.43340) corrected to .39906 for the population as a whole.

6.22. PROFILE OF CHILDREN WHO HAD BEEN ABLE TO ATTEMPT SUBTEST pa2 DURING EXPERIMENT 1.

Table 6.28: Performance of children who had been able to attempt the segmentation task during Experiment 1, on the Test of phonological awareness, Experiment 2.

Subject	sex	pa1	pa2	pa3	pa4	PA total
2	2	30	25	20	18	93
11	2	28	26	17	20	91
21	2	30	30	20	12	92
24	2	30	30	20	19	99
27	2	30	29	19	20	98
32	not in	second	study			

Table 6.29: Performance of children who had been able to attempt the segmentation task during Experiment 1, on the independent variables, Experiment 2.

Subject	EAT	blocks	AM	PM	AD	FB	PL	AUD	MED	PED	ST	SCH
2	53	21	25	38	20	2	1	0	0	0	1	1
11	61	11	19	31	14	1	1	1	0	1	1	1
21	61	30	22	27	18	2	1	1	1	0	10	1
24	68	12	19	29	17	2	0	0	0	1	0	1
27	68	23	28	33	20	2	0		0	1	0	1
32	not in	second	study									

6.23. SUMMARY OF THE RESULTS FROM TESTING AT FIVE YEARS OLD

- Half the variation in phonological awareness scores was accounted for by an equation involving the variables phonological memory, speech production skills and non-verbal intelligence.

- Children with high/low phonological awareness scores showed differences in means on the variables auditory memory, nonverbal cognition, speech production, phonological memory, family background, maternal and paternal education.

- There was a significant correlation between phonological awareness skills and performance on the variables auditory memory, phonological memory, speech production and non-verbal cognition, and a weaker correlation with the variable speech perception.

- Family background and level of paternal education influenced phonological awareness.

- Overall phonological awareness scores correlated highly with all the individual phonological awareness subtest scores.

- A significant proportion of the variance in performance on the phonological awareness subtest rime judgement (pa3) was accounted for by an equation including the variables speech production (EAT), acceptability judgements (pa1), phoneme identification (pa2) and family background (FB).

- Rime judgement scores correlated with the ability to make acceptability judgements and with the ability to identify phonemes.

- The four phonological awareness subtests correlated with different combinations of the independent variables.

6.24. SUMMARY OF CHANGE OVER TIME

- There was a significant change in the variables phonological awareness, speech perception and production, nonverbal cognition, auditory memory, and in phonological awareness subtests pa1-3 between experiments 1 and 2. However, there was no significant change in pa4.

- There was a highly significant correlation between phonological awareness test scores at four and at five years old.

- A significant proportion of the variance in phonological awareness test scores at five years old was accounted for by a regression equation including the variables phonological awareness at four years old, level of parental education and vocabulary scores at four years old.

- Scores on the phonological awareness test at five years old correlated with the following variables tested at four:- speech perception and production, auditory memory, vocabulary, non verbal intelligence, and phonological awareness subtests pa1 and pa4.

- Whilst more children passed each subtest of the phonological awareness test, and the differences between success rates reduced, the order of difficulty of different subtests remained. Pa1 (acceptability judgements) proved the easiest followed by pa4 (feature analysis) and pa3 (rime judgement) with pa2 (phoneme identification) being the most difficult.

- The highest proportion of change in success rates occurred on subtests pa2 and pa3.

- Performance on subtest pa4 (feature analysis) showed a some what different pattern to the other subtests with some subjects performing less well at 5 years old.

- A significant proportion of the variance in performance on the phonological awareness subtest pa3 (rime judgement) tested at five years old was accounted for by a regression equation comprising vocabulary scores at four years old and family background (FB).

- The relative position of children from family background 3, on the test of phonological awareness, decreased in relation to their peers.

CHAPTER 7
Discussion and Conclusions

7.1. INTRODUCTION

The two experiments reported in this thesis were designed to explore the nature of the construct 'phonological awareness' in four and five year old children. Age was held constant (at four years plus/minus 1 month in Experiment 1, and five years plus/minus 1 month in Experiment 2) and the subjects' performance on variables hypothesised to influence phonological awareness was assessed. The variables selected for measurement (see Chapter 4) were, in Experiment 1, speech perception and production, auditory memory, nonverbal cognition, and general linguistic skills; and in Experiment 2, speech perception and production, phonological memory, auditory memory and nonverbal cognition. In addition, information about, sex, family background, presence/absence of older siblings, parental education, schooling and history of ear infections was noted.

7.2. INTERACTION BETWEEN INPUT AND OUTPUT PHONOLOGICAL PROCESSING

There has been much discussion (Chapter 3) about the nature of phonological processing, and of the extent to which the mental operations which make use of the phonological structure of language are related. Section 3.2.2. discussed the argument that models of speech processing which specify separate input and output lexicons necessarily require the status of the internal representations to be specified separately for each lexicon. This level of precision is rarely achieved in the literature, however. Most information processing models make implicit assumptions about the connection between input and output lexicons (3.2.3.) and about the comparable state of the lexicons at any point in development (3.2.4.)

Many of the papers which discuss phonological processing also fail to address the issue of the interactions between input and output processing components, making implicit assumptions about the existence of some form of general, underlying, phonological processing ability (6.3.5.) This view point may have been grounded in the recognition that there is interaction between phonological processing in fields such as perception, production, memory and awareness (3.5.) The proposal that input and output phonological processing are linked (Menn, 1994) is finding more explicit form in the connectionist models of processing (Stoel-Gammon and Stemberger, 1994; Chiat, 1994; 3.2.3.). Such models stress simultaneous processing, and conceptualise interconnections between all levels of processing.

Observations from subjects' performance in the current investigation demonstrated the difficulties inherent in failing to take an interactive view of processing. The test of Phonological Awareness was designed (with the exception of the correction component of subtest pa1 (acceptability judgement)) to focus primarily on input phonological processing and to minimise the overt influence of output phonological processing skills. The expectation was that, in the error detection task in subtest pa1, and in subtests pa2, pa3, and pa4, the child would not be required to encode phonological information; that is, would not have to produce a verbal response from whose phonological structure metaphonological knowledge would be inferred.

However, observation of the subjects' responses during testing led to the conclusion that, in addition to the output phonological processing required in the 'correction' component of subtest pa1, subtests pa2 and pa3 also appeared to involve the output modality. When carrying out subtest pa1 (including the correction task) and subtest pa4 the children's responses were noted to be immediate with no time lag. However, performance on subtests pa2[1] and pa3 were often noted to involve delay while the child silently rehearsed, or repeated, the target item(s). (An interesting exception, however, was subject 21 (see 6.2.6., 6.2.7. & 7.9.) who responded immediately on subtest pa2.)

[1] This comment applies only to the children who attempted the task. i.e. did not adopt the strategy of giving a consistent (automatic) no/yes response (see section 5.10.2.)

Such repetition could be argued to result from the child recoding information for processing and retention in working memory (Naslund and Schneider, 1991; 6.3.5.). Marion, Sussman and Marquardt (1993) (3.2.6.) have argued that overt, or covert, articulation facilitates retention of phonological information. They suggest that such an effect may be particularly noticeable when children are dealing with novel items. This links with Torgesen, Wagner and Rashotte's (1994) hypothesis (3.2.6.) that the representations used to store verbal material for recall/accessing in metaphonological tasks are composed primarily of the phonological features of the stimuli. This thesis argues that a combination of input and output phonological lexicon processing would be implicated in the recoding process making the notion of the contribution of one lexicon, at best, difficult to assess and, at worst, meaningless.

There is some confirmation for this view from the correlational analysis. At five years old the speech production assessment (EAT) correlated with subtests pa1, pa2 and pa3 suggesting the possibility that output phonological processing is involved in some way in all three tasks. However for four year old subjects, the EAT was significantly correlated only with subtest pa2 reflecting the nature of these children's metaphonological skills which were biased towards tasks involving sensitivity to phonological information (see section 7.6). Within the current state of knowledge it would seem most profitable to take an interactionist view of the phonological processing system, whilst trying to evaluate the contribution of different processing skills. This chapter will present a synergistic model of emerging phonological awareness (7.11.).

7.3. THE CONTRIBUTION OF INDIVIDUAL PHONOLOGICAL PROCESSING ABILITIES

A methodological issue which has influenced previous studies (3.2.6.) has been the failure to ascertain whether the variables which are included in studies of phonological processing measure different abilities in distinct, even if related, domains (Wagner, Torgesen, Laughon, Simmons and Rashotte, 1993). The bivariate analysis of the data from both Experiments 1 and 2 indicated significant (often highly significant) correlations between performance on the tests of phonological awareness, speech perception and production, auditory memory and (in Experiment 2) phonological memory. However, results from the multivariate analyses suggested that these variables made independent contributions to the variation in performance on the phonological awareness test.

The linear regression carried out on the data included calculation of colinearity between independent variables included in the equation. During Experiment 1, however, only one variable was included in the equation leading to the conclusion that this variable (speech perception) made an independent contribution to the variation in phonological awareness. Whilst the predictor variables together accounted for just over 50% of the variation in the dependent variable phonological awareness, in Experiment 1, performance on the test of speech perception (AD) accounted for 25% of this variance, corrected to 23% for the population from which the sample was drawn.

In the regression analysis carried out on the data from Experiment 2, the tolerance calculations indicated that there was no evidence of colinearity between any of the three independent variables (phonological memory, speech production and nonverbal cognition) in the equation. It appears that these variables made an independent contribution to the variation in performance on the test of Phonological Awareness.

7.4. THE INTERRELATIONSHIP BETWEEN SPEECH PERCEPTION AND PHONOLOGICAL AWARENESS

The results of the linear regression carried out on the data from the four year old children point clearly to an influential role for speech perception skills in the development of phonological awareness which is not evident for the five year old children. How can this finding be explained? Sections 3.2.8. & 3.2.9. discuss current theoretical explanations of the relationship between perception and production in the processing of phonetic/phonological information, and in the development of the child's phonological processing system. This thesis argues that there is explanatory potential (3.2.4.) in Waterson's (1987) model of phonological processing; a perceptually biased theory of development. Early perceptual limitations are argued to result (initially) in incomplete phonological representations which will lead to problems/limitations on the phonological processing system as a whole.

There is further evidence from studies of language disorder (Constable, Stackhouse and Wells, 1994; Catts, personal communication; Bridgeman and Snowling, 1988) that provides a framework for conceptualising the influence of perceptual skills on phonological processing. These clinical studies suggest that perceptual skills continue to develop well into middle childhood, particularly those skills required for tasks with complex processing demands (3.2.5.).

Within the developmental process, perceptual skills appear to be of central importance in the establishment and refinement of phonological representations from imprecise to precise entities (3.2.4.- 3.2.6.). 'Fuzzy' representations will have implications for the phonological processing system as a whole, and particularly for operations which require the integration of different processing components as in a phoneme oddity task. For example, the findings of studies of phonologically impaired children, who might be hypothesised to have incomplete systems of phonological representations, do indeed suggest that such children have poorer metaphonological skills than age matched peers (for example, Howell, 1989) Magnusson, 1991; 3.5.2.). There are at least two potential explanations for this phenomenon. Such children may have a poorly established substrate of phonological representations and/or they may have difficulty accessing phonological codes; both explanations possibly being linked to existing or prior perceptual constraints.

The current thesis argues that performance on phonological awareness tasks, which require the recognition, store, accessing and manipulation of phonological forms, will be influenced by the precision and accuracy of internal phonological representations (3.2.6.). This conceptualisation of the relationship between phonological awareness and speech perception would predict that, as the child and his/her system of phonological representations mature, the influence of perception should decrease.

This does indeed appear to be the trend demonstrated by the findings of the second phase of this study. When a linear regression analysis was applied to the data from the five year old children, speech perception scores did not account for a significant proportion of the variance in the dependent variable, phonological awareness. The independent variables in the equation (phonological memory, speech production and nonverbal cognitive skills) accounted for 52% of the variation in phonological awareness, corrected to 47% for the population as a whole. Of the variables within the equation, phonological memory was the most influential contributor followed by speech production, and then nonverbal cognition (6.12.). Altogether the independent variables accounted for 72% of the variation in the dependent variable, phonological awareness.

7.5. DEVELOPMENTAL CHANGES IN THE RELATIONSHIP BETWEEN PHONOLOGICAL AWARENESS AND THE INDEPENDENT VARIABLES

7.5.1. Issues of measurement

How might the different pattern of variables influencing phonological awareness in these children at four, and at five, be accounted for? There are at least three possible explanations, the first two relating to measurement issues. Firstly, in Experiment 1, phonological memory was not explicitly measured as it was in Experiment 2; that is, by a nonword repetition task (PM). Instead the contribution of memory was assessed using a sentence repetition task (AM). Whilst the correlation between performance on the AM and PM tests (during the second experiment) was high, auditory memory skills did not account for sufficient variation in the dependent variable to be included in the regression equation. Thus, the contribution of phonological memory might not have been accurately assessed during Experiment 1.

7.5.2. The emergence of differentiated phonological processing skills

To rule out this explanation Experiment 1 would require to be repeated including more detailed assessment of phonological memory. However, there are grounds for suggesting that the effect of the nature of the assessment of phonological memory is not a sufficient explanation for the findings of this study. It can be argued that, due to the mutual dependency of both phonological awareness and phonological memory on the quality of the child's internal representations, the two abilities might initially be inseparable for measurement purposes.

Torgesen, Wagner and Rashotte (1994) (3.2.6. & 6.3.5.) found that measures of analytic phonological awareness and phonological coding in working memory assessed the same construct in the six year old, preschool, children they studied. As development progressed, these skills underwent differentiation so that by the second year of school they could be assessed as separate abilities. Naslund and Schneider (1991) argue similarly that, for beginning readers, the construct 'phonological awareness' may reflect a more primary factor; the ability to sufficiently retain and access information in memory, thus allowing the child to reflect on the phonological components of speech.

Performance on phonological memory tasks, and the child's ability to acquire linguistic knowledge about phonology, might both be affected by degraded phonological representations. The separation of phonological awareness and phonological memory abilities could be hypothesised to be related to the gradual establishment of a system of precise, intact, phonological representations. Thus, it could be argued that the findings seen in the current investigation are related to the gradual emergence of phonological memory as an ability distinct from phonological awareness.

However, one difficulty with this explanation is that (as has been argued in sections 3.2.4., 6.3.5. & 7.5.3.) there is also a close link between speech perception and the development of internal phonological representations. It might be expected that, in addition to the influence on phonological memory and phonological awareness, performance on the speech perception test (AD) would also be influenced by the quality of the internal representations. However, speech perception is emerging as an independent explanatory variable in Experiment 1. It would appear that it is necessary to look elsewhere to build a conceptual framework that will account for these results.

7.5.3. The changing focus of phonological awareness

Watson and Miller (1993) (3.2.5.) suggest that there may initially be a resource allocation trade off with speech perception requiring more resources, leaving less available to perform recall, retrieval and manipulation tasks. This hypothesis would fit with the finding of the current thesis that speech perception abilities were the most important source of variation in metaphonological processing in the four year old children, whereas at five years of age phonological memory, speech production and nonverbal cognition made the most significant contribution. If performance on tasks of speech production are taken to reflect the quality of internal phonological representations (3.2.6., 3.4. & 4.8.2.1.); phonological memory skills to allow storage and accessing of phonological information; and nonverbal cognition to be implicated in the manipulation of phonological form, then the findings from Experiment 2 support the notion that the development of phonological and cognitive skills both support the change in phonological awareness that occurs with age.

It can be argued that the importance of speech perception at four years of age is that it is the skill which allows sensitivity to phonological information. However, by the age of five, the child becomes able to perform explicit manipulations which require the ability to retain information within short term memory (PM) and to engage in processing activities which draw upon cognitive skills. (See section 7.6 below)

7.6. EVIDENCE FROM PERFORMANCE ON INDIVIDUAL SUBTESTS OF THE PHONOLOGICAL AWARENESS TEST

Is this hypothesis about the development of phonological awareness supported by performance on the individual subtests of the Phonological Awareness Test? The order of difficulty for the subtests (pa1, pa4, pa3, pa2) was the same for each age group with a significant increase in skills for all but subtest pa4. Comparison with other studies (e. g. Howell, 1989; Chaney, 1992) is difficult due to differences in, for example, subject populations, task foci, and task demands. However, this progression reflects that generally reported in the literature (1.3); with first, awareness of syllables, then intrasyllabic units and finally, segmental analysis. It is important to consider whether this hierarchy of difficulty reflects a hierarchy of task demands which supports the hypothesis that developing phonological awareness requires the development of speech processing, phonological memory, and phonological analysis skills.

Table 4.2. summarises the individual subtest formats in terms of the (hypothesised) processing involved (judgement, production, detection and manipulation), number of demonstration items, the response required, the nature of the stimuli and the mode (auditory or visual) of presentation. The subtest on which most (93.5%) four year old children reached criterion (Acceptability judgement: subtest pa1) was designed to involve real word stimuli, four demonstration items, auditory and visual mode of presentation and required judgement and production skills but not detection or analysis abilities. Thus, it might be hypothesised that this subtest required perceptual skills, and sensitivity to phonological structure, but no manipulation of the phonological structure.

The same task demands appear to be involved in performance on the second easiest subtest for the four year old children. This was the feature analysis subtest (pa4) on which 65.2% reached criterion. This subtest involved single phoneme items, five demonstration items, a pointing response and detection of a match for target. If detection is accepted to be a more complex skill than judgement, it would appear logical that this subtest (pa4) would be significantly more difficult for the children than subtest pa1.

However, there was a large difference between performance on subtest pa4 (Feature analysis) and performance on subtest pa3 (Rime judgement) on which latter test only 19.6% of subjects reached criterion despite the fact that subtest pa3 also involved detection of a match with the target. The difference between subtests pa4 and pa3 lay in the responses required (yes/no for subtest pa3 and pointing for subtest pa4) and in the nature of the items (items with a CVC syllable structure in subtest pa3, and items with a CV syllable structure in subtest pa4)

The difference in response would appear to be negligible as a yes/no response can also be indicated nonverbally, by head movements. The difference in task items is more interesting. There has been widespread acknowledgement (1.3.) that the child is sensitive to syllabic and intrasyllabic units at an earlier age than phonemes. However, the results presented here appear to support clinical findings (Howell and Dean 1994; 4.7.5.) that children can perform feature analysis at a younger age than rime identification. At the age of five years 75.6% of subjects reached criterion on subtest pa3 (rhyme judgement); evidence that by this age there was reliable detection of specified intrasyllabic units.

Subtest pa2 (Phoneme identification) was virtually impossible for the four year old children with only 6 children making a recognisable attempt at the task (5.10.2.) and only 5 reaching criterion. This task involved real word stimuli, four demonstration items, a yes/no response and segmentation skills. At five years old, 68.3% of the subjects reached criterion, with no significant difference in performance on subtest pa2 between children who were/were not attending school (see section 7.9). This finding, together with the results of the multivariate analysis (see section 7.4), would appear to support the hypothesis that at four, children appear to perform best on tasks that require them to perceive and judge phonological structure; between four and five the ability to detect and match phonological structure develops; and by five the child is able to perform some forms of analysis.

This explanation of the result of the regression analysis receives some support from the results of the bivariate analyses. Auditory memory[2], speech perception and production, and non verbal cognitive skills all changed significantly between first and second testing, reflecting expected developmental change. At the age of four both auditory memory and speech perception correlated significantly with subtests pa1 (acceptability judgements) and pa4 (feature analysis) and speech production with subtest pa2 (phoneme identification). (There was also a weak correlation between nonverbal cognition and subtest pa1). However, by five years of age the significant correlations were between auditory (and phonological) memory and subtests pa2, pa3 (rime judgement) and pa4; and between speech production and subtests pa1, pa2 and pa3 (and a very weak correlation between nonverbal cognition and subtest pa2. (5.8.3. & 6.11.3.)

The results of these correlational analyses require to be treated with some caution, however. The analyses carried out were non-parametric as the univariate analyses (5.10.; 6.13.) of performance on the individual subtests indicated that the distribution of scores was somewhat skewed. This finding is not surprising given the relatively small number of items in the individual subtests, the lack of standardisation data and the requirement of the overall test to measure performance reliably at four and at five. [3]

However, linear regression is a robust technique and multivariate analyses were carried out to determine which of the independent variables accounted for a significant proportion of the variation in the subtests of the phonological awareness test at four, and at five, years old (5.13., 6.15.). Only two of the analyses met the assumptions for the linear regression (5.91.) and thus only these are discussed further.

[2]Phonological memory was not explicitly tested during Experiment 1. See section 6.3.
[3]For this reason the focus of the analysis and discussion has been the overall scores on the phonological awareness test. This test was designed (4.7.) to have a large number of items, to span a range of abilities cited in the literature as being implicated in the skill phonological awareness; that is to reliably sample the construct 'phonological awareness'.

On testing at four a significant proportion of the variance in the subtest pa4 (feature analysis) was predicted by scores on the auditory memory (AM) test (5.13.). At five years old a significant proportion of the variance in the scores on the subtest pa3 (rime judgement) was estimated by an equation involving tests of speech production (EAT), family background (FB), and scores on the subtests pa1 (acceptability judgements) and pa2 (phoneme identification) (6.15).

These results are somewhat difficult to interpret, referring as they do to only two individual, and different, subtests. However, the results of the linear regression of the data from the testing at four emphasises the importance of auditory memory skills in supporting phonological awareness at four (see 7.13.3 for a discussion of the implication of this finding). Further, the results of the multivariate analysis of variation in scores on subtest pa3 at five years old supports the correlational analyses (5.11.; 6.14) in suggesting that, by this age, the ability to detect and analyse rime is closely related to other metaphonological skills. It is possible to argue that if the construct 'phonological awareness' is tested by a single test, a test of rime awareness might be most appropriate (see also 7.12.6.).

Comparison of performance on the individual subtests of the phonological awareness test also supports the notion of a continuum from holistic to intrasyllabic units to segmental awareness. It is interesting that, at four years old, overall performance on the test of phonological awareness correlates with all the subtests except pa2 whereas at five years old, it correlates with all the subtests of this test except pa4; further supporting the idea of a move away from a holistic to a segmental focus.

This shifting pattern of the influence of phonological processing skills and the progression, demonstrated between first and second testing, in the ability to carry out phonological awareness tasks of varying complexity support the hypothesis proposed in this thesis. At four years old children appear to perform best on metaphonological tasks involving detection and judgement. By five years old, children can perform tasks such as phoneme identification because they have developed phonological memory skills which allow them to hold items in memory, adequate internal phonological representations which they can manipulate, and the nonverbal cognitive skills to perform such an analysis.

7.7. THE INTERACTION BETWEEN COGNITIVE AND LINGUISTIC (SPECIFICALLY PHONOLOGICAL) FACTORS IN THE DEVELOPMENT OF PHONOLOGICAL AWARENESS

7.7.1. Levels of awareness

The notion that the development of phonological as well as cognitive skills support the changes in phonological awareness that occur with age can be related to both theoretical and experimental studies of metaphonological abilities.

Torgesen, Wagner and Rashotte (1994) (3.2.6.) argued that the results of their study supported the notion of a distinction between phonological sensitivity and explicit manipulation of sounds in words; with the latter not developing until significantly later; perhaps only after literacy training. This distinction reflects the theoretical accounts which have conceptualised the development of metaphonological skills as being a shift from implicit to explicit awareness (Bialystok and Ryan, 1985a; Karmiloff-Smith, 1986; Galambos and Goldin-Meadow, 1990; Gombert, 1992).

Gombert's (1992) model of the successive phases of the development of phonological awareness, is a useful example (2.2.2.) because of its focus on the influence of comprehension, as well as of production. Gombert argues that the first phase is the development of the necessary linguistic skills, specifically including input, output and central processing of linguistic information. Such a phase can be related to the development of a functional system of internal phonological representations sufficient to underpin phonological processing, including the development of metaphonological abilities.

It is possible to argue that the correction component of subtest pa1 (acceptability judgement) is a measure of functioning at this low level of awareness (4.7.2.). However, a stronger position can be adopted, questioning whether this subtest is actually a measure of phonological awareness at all but an alternative assessment of phonological codes; the precision of underlying phonological representations. As such this subtest would be hypothesised to replicate the findings of the speech production assessment (4.8.2.) in that both rely on spontaneous naming to give an indication of underlying phonological processing. In this experiment the speech production assessment did not take the form of a detailed phonetic or phonological analysis but was a yes/no measure of phonetic accuracy, an identical scoring method to the 'correction' component of subtest pa1, further strengthening the link between these two measures.

This view of the underlying skills tapped by subtest pa1 would be at odds with several studies such as that of Galambos and Goldin-Meadow (1990) and Howell (1989) who have conceived of similar assessments to be a measure of early phonological awareness. In fact, correlational analysis (see Appendix 6) did not find a significant relationship between performance on the 'correction' component of subtest pa1 and the measure of speech production. One possible explanation for this finding is that subtest pa1 was not constructed specifically to be sensitive to the phonological system of four year old children (4.8.2.1.) and thus scores might have over represented speech processing skills compared to the estimate obtained from the assessment of speech production (EAT). The potential overlap between these two measures cannot be disregarded.

The second phase of Gombert's (1992) model involves the development of implicit awareness (2.2.2.) and Gombert suggests that recognition of dissonance (i.e. a mismatch between meaning and form) becomes possible at this level of development. This level is implicated in the successful completion of the acceptability judgement component of subtest pa1 where the subject is required to separate form from meaning (4.7.2.). Gombert (1992) postulates that the child becomes increasingly able to access a developing internal rule system to allow more explicit judgements to be made.

During Gombert's (1992) third phase of metaphonological development, awareness is seen as becoming (optionally) explicit. If the task demands it, the child can consciously access knowledge and intentionally control process. Finally, metaphonological processing becomes automated such that it is always available for conscious access. As presented (Gombert, 1992) these final two phases of metaphonological development seem a rather under specified description of phases which include much change. Gombert's (1992) model requires to be further developed to account for the progression, for example, from awareness of rime to awareness of phonemic segments (1.3.2. & 1.3.3.). It is necessary to postulate a hierarchy within these phases based on such factors as increasing cognitive control (i.e. developing phonological memory), and the child's developing capacity to move from a holistic, through an intrasyllabic, to a segmental focus. Such a model would account for the child's sequential success on tasks of syllabic (subtest pa4), intrasyllabic (subtest pa3) and segmental (subtest pa2) processing.

To some extent Gombert (1992) alludes to this question by suggesting that not all linguistic skills become the subject of reflection at the same time due to the high cognitive load imposed by conscious control. This notion could be extended to suggest that the high cognitive 'cost' of control can initially only be 'paid' when the processing units are well within the child's linguistic processing capacities; i.e. that control can initially be applied to syllabic units, and only later to segmental units (or phonemes).

7.7.2. The structure and control of analysed knowledge

Bialystok and Ryan (1985a) have proposed a useful framework for linking the influence of linguistic and cognitive factors in the development of phonological awareness. They argue that increasing awareness is due to a combination of increasing 'analysed knowledge' and growing 'cognitive control'. Analysed knowledge refers to the ability to structure and classify the knowledge base. Bialystok and Ryan's (1985a) notion of cognitive control is linked with changes in memory and cognitive functioning; arguing that developing phonological awareness results from the ability to access information and analyse it.

The findings of this thesis allow both extension and confirmation of Bialystok and Ryan's (1985a) model as it might be applied to phonological awareness. The extension involves the elaboration of the notion of 'knowledge' to include both a more explicit account of the nature of the knowledge base, and of the way in which development of this knowledge base occurs. Sections 3.2.2., 3.2.3. & 6.3.5. discuss the complexity of the internal phonological processing system which is argued to underpin phonological processing in such domains as speech processing, phonological memory and phonological awareness.

This thesis argues that Bialystok and Ryan's (1985a) notion of knowledge as coded classes of alternatives can be expanded, in the context of phonological processing, to incorporate a more specific conceptualisation of the required knowledge base. The notion of analysed knowledge can be seen as involving a system of internal representations of linguistic forms which underpin both input and output processing and which become increasingly precise as development continues (3.4.). The results of the multivariate analyses of the data from the current investigation provides evidence to support the literature which suggests that the move to the establishment of a stable, functional, system of precise phonological representations can be related to both perceptual processing (Waterson, 1987; Hewlett, 1990) and to cognitive changes (Vihman, Velleman and McCune, 1992) with the interconnections between different influences being of marked importance (Menn and Matthei, 1992).

A more specific view of the nature and development of concepts such as 'underlying representations' (3.2.3.) or 'analysed knowledge' (2.2.4.) allows a fuller understanding of potential influential factors, and of the inter-relationship with developing phonological awareness. This clarification is particularly valuable in the light of the confirmatory evidence for Bialystok and Ryan's (1985a) model that the results of the current investigation has provided.

This support arises from the results of the linear regression which highlight phonological memory, speech production and nonverbal cognition as the variables which contribute significantly to the variance in phonological awareness in five year old children. This finding provides experimental support for Bialystok and Ryan's (1985a) contention that it is changes in both analysed knowledge (in this case represented by scores on the speech production and the phonological memory tasks), and cognitive control (as measured by performance on the phonological memory task and the assessment of nonverbal cognition).

To some extent phonological memory, relying as it does on both processing abilities and on the quality of the internal phonological processing system, may underpin both Bialystok and Ryan's (1985a) dimensions providing the link between these dimensions of change, and accounting for movement on both the parameters of phonological processing and cognitive control. However, the influence of other factors, in particular the status of the system of internal phonological codes/representations, cannot be discounted (Wagner, Torgesen et al, 1993). Additional evidence from the current study can be used to illuminate further the interrelationship between the variables which contribute to developing phonological awareness.

7.8. THE INFLUENCE OF NON-PHONOLOGICAL FACTORS ON PHONOLOGICAL AWARENESS

The information gathered within the two experiments allowed the evaluation of the influence of several non-phonological factors, judged potentially to be relevant on the basis of the literature review (Chapters 1, 2, 3, 4). Data was gathered on sex, history of ear infections, family background, parental education, and, in the second experiment, attendance at school and reading skills. In the first experiment, ability to read was an exclusion criterion although none of the children tested were able to read any words on the Schonnell Reading Test (ST).

At four there was no significant correlation between any independent variable and phonological awareness (5.11.). However, the groups of children with high, and with low, phonological awareness were significantly different on the variables speech perception, auditory memory and vocabulary, suggesting that these skills are important for the development of phonological awareness. Further, the bivariate analyses (6.11.1.) revealed significantly different auditory memory scores for children from family backgrounds 1 and 2, and for children whose mothers and/or fathers did/did not have post school education.

The bivariate analysis carried out on the data from the five year old children still showed significantly different auditory memory scores for children whose mothers and/or fathers did/did not have further education. These are interesting findings in the light of the fact that phonological memory, not explicitly measured at four years old (6.12. & 7.3.), accounted for a significant proportion of the variance in five year olds' scores on the phonological awareness test.

Further evidence about the influence of home background came from the bivariate analysis of the scores of children rated, at five years old, as having high, or low, phonological awareness (6.11.2.) The scores of these two groups were significantly different on the variables family background, maternal education and paternal education. There was also a high correlation between the scores from the phonological awareness test and the variables family background and paternal education. This finding is particularly interesting because the variables family background and parental education did not appear influential for the metaphonological processing skills of four year old children; there was no correlation between these variables in the analysis of the data from Experiment 1 (5.12.).

Overall, these results suggest that family background, particularly parental education, (as the family background calculation includes this information (4.10.) are important in the development of phonological awareness. This evidence supports previous studies (for example, Bryant, Bradley, MacLean and Crossland, 1989) in indicating the importance of parental educational levels. However, whilst children from family background 3 (FB3) were included in the correlational and multivariate analyses, they were excluded from the bivariate analyses (differences between means) because their number was so small.

It could be argued that the subject population investigated within this study showed a bias towards children from family backgrounds 1 and 2. The results must certainly be interpreted with this factor in mind. However, despite the relative homogeneity of the family background within the subject group, there was variation, perhaps due to the fact that the FB calculation (4.10.) included data on maternal and paternal education as well as employment. Despite the apparent homogeneity, family background and educational levels did appear to emerge as important factors.

Some interesting insights can be gained from considering the scores of the six children from the subject group who were categorised as belonging to FB 3 (6.16). These children were all tested at four years old and followed up at five. At four, their mean phonological awareness scores were almost equivalent to those for the group as a whole. However, mean scores on the tests of nonverbal cognition, speech production, speech perception, auditory memory and vocabulary were all below the lower limit of the confidence interval for the group as a whole. Whilst the FB 3 group's nonverbal cognition scores at five years old were within the confidence interval for the subject group as a whole, the scores on the variables phonological awareness, speech perception and production were all below the lower limit of the confidence interval for the group as a whole.

This evidence, which suggests that family background and parental education levels were important influences in the development of phonological awareness, would have been confirmed by the inclusion by substantial numbers of children from a wider variety of social groupings. The interesting question is to what extent the relationship between family background, or parental educational level, and phonological awareness is direct; perhaps relating to factors such as how often parents read to a child, or talk about the way in which words are said, read or spelt. Even if reliable data could be gathered about child rearing practices it is unlikely that such a relationship could easily be explored. For example, Chaney (1994) attempted to investigate the 'literacy involvement' of families through a detailed questionnaire. She found that when effects of children's general language skills were controlled for, the effect of family literacy levels of children's metalinguistic performance was negligible (4.10.1.). This outcome suggests that family background has its primary influence on the children's general language functioning, which Chaney (1994) argued was one of the main influences on metalinguistic processing.

An alternative explanation would be that both family background and phonological awareness are related to a third factor, such an nonverbal cognition or general linguistic skills, which influence parental educational and occupational achievement. However, the fact that neither family background nor parental educational levels accounted for a significant proportion of the variance in phonological awareness at four or five years old, suggests that the relationship between these variables and phonological awareness is through a third factor.

It is interesting, in the light of the discussion in this thesis, that the relative position of the children from FB 3, with regard to performance on the test of phonological awareness, decreased in relation to their peers. At four years old their mean scores were similar to those of the group as a whole, whereas at five years old it had dropped markedly (6.16). It could be argued that this change reflects the hypothesised change in the nature of phonological awareness discussed in section 7.7. If it is argued that phonological awareness at four years old reflects a perceptually based sensitivity to phonological information, whereas at five years old phonological awareness involves retention, accessing and analysis skills, then it can be hypothesised that the four year old child from family background 3 is less disadvantaged as perceptual judgements may not be implicated in the generally lower performance levels.

There is some support for this tentative hypothesis in the fact that the scores of the four year old children from FB3 on the test of speech perception were only marginally below the lower limit of the confidence interval for the group as a whole (6.16) suggesting that the perceptual skills required to complete the metaphonological tasks were relatively good compared with the group as a whole. At five years old, when metaphonological abilities begin to include the need to retain (phonological memory), access (phonological processing), and analyse (nonverbal cognition) the children from FB 3 are substantially more disadvantaged as their cognitive and linguistic processing skills have fallen behind their peers. However, there is no firm evidence for such a contention and further investigation of a larger group of children from a similar social grouping would be required. Testing would optimally take place at a younger age than four years so that differences between implicit and explicit (see section 7.7.1.) phonological awareness would be better highlighted.

7.9. INFLUENCES ON SEGMENTATION, AND ON LITERACY, SKILLS

The findings of previous studies (1.3.3.3.) might have led to the prediction that attendance at school would influence segmentation skills due to the hypothesised relationship between literacy training and the development of metaphonological skills such as phoneme segmentation. In the current investigation there was no significant relationship between schooling and performance of the group at five years of age on either the overall phonological awareness test or the individual subtests. This is perhaps not surprising as the individual subjects had only been at school for about three months.

However, the relationship between segmentation skills and literacy can be considered further by examining the performance of the 5 children (6.17.) who reached criterion on subtest pa2 (phoneme identification) at four years of age, and those five year old subjects who were able to read one or more items on the reading assessment (ST). While it is recognised that a group of five subjects is a very small number from which to draw general conclusions, the single case study data provided by these subjects can illuminate the discussion.

The five children (S 2, 11, 24, 27, 32) who reached criterion on subtest pa2 (phoneme identification) during experiment 1 had scores (out of 30) ranging from 19 (S 27) to 25 (S 24) with a mean score of 21 (6.17.). All were girls. These children's mean phonological awareness score was above the upper limit of the 95% confidence interval for the subject group as a whole, as were their scores on the test of speech production. Their scores on the tests of nonverbal cognition and of speech perception were at the upper end of the confidence interval and the mean of their scores on the auditory memory task was almost the same as the mean for the subject population. These five children were scoring in the upper ranges of the distribution of all these variables.

Four out of these children came from family background 2 (4.10) and four of the households had one parent who had had post school education. Only two of the five had older siblings and there was no observable bias with regard to a history of ear infections. All these five children were able to give word/phoneme explanations during subtest pa1. Of the five children, two (S 2, 24) came from the same local authority nursery, two from different local authority nurseries (S 11, 32) and one (S 27) from a private nursery. Thus, this subgroup of subjects was alike in its high level of performance on all variables tested, but had been exposed to a variety of environmental influences.

When the subject group was retested at five years old, Subject 32 could not be contacted. Of the remaining children, two (of the five) children who had reached criterion on subtest pa2 at four years old were two (of the three) children who showed evidence of some reading skills at five years old (6.17.). Subjects 2 and 11 both read one word on the reading test. These two children scored above the upper limit of the 95% confidence interval on tests of phonological awareness and phonological memory. One was scoring at the upper limit of the confidence interval on the tests of nonverbal cognition and speech perception, and the other on the test of speech production. Both these children attended the same school.

The third child who showed evidence of being able to read at five years old read ten words on the reading test. Interestingly, this child (S 21) had not scored above criterion on the subtest pa2 at four years old, achieving a score of 15 out of 30. However, at four she was scoring above the upper limits of the confidence interval on the test of auditory memory. She was able to provide word/phoneme level explanations on subtest pa1. She came from family background category 2; had older siblings, a history of ear infections and her mother had had post school education. At five years old, subject 21 was at the local authority school in whose nursery she had had a placement. On second testing, this girl scored above the upper limit of the confidence interval on the variables phonological awareness, speech production, auditory memory and phonological memory, and was at the upper limit on the test of speech perception. To summarise, all three children who showed evidence of being able to read at five years old were high performers on testing at four and five, were female and were attending school.

The final two children who scored above criterion on pa2 at four years old did not demonstrate any evidence of reading at five. However, both continued to score above the upper limits of the confidence interval on the tests of phonological awareness, speech production and phonological memory. One scored highly on the variables nonverbal cognition, auditory memory and speech perception, whereas the other was within the range of the subject group on the tests of auditory memory and speech perception but scored well below the lower limit of the confidence interval on the test of nonverbal cognition. Otherwise, these two girls had identical family background categories, had older siblings, had fathers who had had post school education and both attended local authority schools.

The finding of this study, that only 5 out of 45 four year old children could score above criterion on a phoneme segmentation task supports evidence from previous studies that this skill is particularly problematic for preliterate and illiterate subjects (1.3.3.3. & 2.3.4.3.). However, the fact that five preliterate children did manage to perform this task at a level well above chance suggests that there must be caution in drawing such a conclusion. Task demands can influence the outcome of studies, and make comparison of findings problematic (3.5.6. & 4.7.1.), but there are other potential explanatory factors.

It could be argued that these five children had all been involved in early literacy training at nursery or at home. However as the five came from different pre-school placements and performed differently to others in these placements, this does not appear to be a sufficient explanation. Alternatively, it can be hypothesised that different factors can work in combination to allow such metaphonological skills to develop; factors such as the (above average) phonological processing, phonological/auditory memory and cognitive skills that these children demonstrated.

The evidence of segmentation skills provided by the preliterate five year old children is also interesting. 68.3% of the five year old children reached criterion on subtest pa2 suggesting that they had some segmentation skills. In view of the hypothesised relationship between literacy training and segmentation skills (1.3.3.3. & 2.3.4.5.) this is an interesting finding. The case study profiles of the children who did show some evidence of emerging literacy skills can add to the understanding of the concept of 'phonological awareness'.

Whilst it is recognised that this subgroup is a very small number on which to base even a tentative hypothesis, and while it is possible to argue that recognition of only one word does not constitute 'reading'; it is the uniqueness of these subjects that is interesting. Only three 5 year old children out of 41 were able to read one or more words on the reading test, attendance at school did not influence performance on subtest pa2 (phoneme identification) nor did it account for a significant proportion of the variance in phonological awareness scores on second testing. Further, there is emerging evidence that good performance on tests of phonological awareness can be demonstrated by subjects who have different profiles of contributing abilities.

7.10. ANALYSIS OF ABILITY TO PROVIDE EXPLANATIONS

The ability to provide explanations was not included in the overall calculation of phonological awareness for two reasons :-

1. The explanations (which were not the main focus of the study) were difficult to analyse in anything other than in the rather gross way described in 5.10.1. The explanations were coded in relation to their focus rather than their form, as the metaphonological nature of the task made an analysis system such as that described in Donaldson and Elliot (1990) difficult to implement. The nature of the analysed event was not a temporally based one involving, for example, cause, effect and outcome.

2. The indication of the child's awareness of the speech sound system that such a task would give will be influenced by the level of general linguistic development. For example, a child with poor syntactic processing will be prevented from demonstrating the true level of their appreciation of the nature of the manipulation of the speech sound system because language processing skills are not intact.

However, the ability to produce explanations is of interest because it provides an alternative route to the understanding of the level of phonological awareness. In Chapter 2 (2.2.3.) there was a discussion of theoretical models which view the emergence of phonological awareness as a continuum from implicit to explicit awareness. The ability to describe/talk about the phenomena observed and analysed must (if general language processing skills are intact) reflect the emergence of conscious metaphonological skills. Further, the explanations provided additional information about the shift in focus from meaning, to form; a shift noted to occur as metaphonological skills develop (2.2.4.2.)

As Galambos and Goldin-Meadow (1990) argue, the ability to produce such explanations necessarily requires the child to perform the perceptual and analytic processing underlying the initial judgement (see section 7.6). However, these are not sufficient skills as the results of the analysis have to be 'coded' in the form of a linguistically based output; a sentence giving the explanation.

The data gathered during Experiment 1 allows a closer examination of the factors potentially implicated in the child's ability to provide explanations. The analysis system was relatively crude; the child was taken to be able to provide explanations if s/he is able to give 'word centred', and/or 'segment centred', explanations. These were explanations focusing on the phonological *form* of the word or segment and were differentiated from meaning based explanations (5.10.1.1.) in which the child commented on the fact that the speaker had not conveyed the correct meaning. The data from Experiment 2 is less useful because by this stage almost all children were able to reach this level of performance.

At four years old, 30 children were able to provide word, and/or segment, centred explanations. These children's mean scores were just over the mean for the group as a whole for the variable speech perception; towards the upper limit of the confidence interval for the mean on the variables phonological awareness, speech production, nonverbal cognition and auditory memory; and just over the upper limit of the confidence interval for vocabulary skills.

In contrast, the 16 children who could not give word, and/or segment, centred explanations were at the lower limit of the confidence interval for the group as a whole on the variable speech perception; just below the lower limit of the confidence interval for the variables phonological awareness, speech production and auditory memory, and below for vocabulary scores.

This case study data would, on initial consideration, seem to support the tentative suggestion that the ability to provide explanations is a specific form of phonological awareness which is not only dependent on cognitive and phonological processing but also on general linguistic skills. The largest contrast between the two groups' abilities lay in their performance on the vocabulary test (4.13), commonly taken to reflect general language processing skills.

However, if the data from the group who produced no explanations at all is examined, it becomes obvious that the picture is not this simple. The group of 5 children who gave no explanations at all during Experiment 1 had slightly higher mean scores on the variables speech production, vocabulary and speech perception than the group who produced only limited explanations, and had a markedly higher mean score for the variable nonverbal cognition.

Such evidence reinforces the hypothesis, argued above (see section 7.7.3. & 7.9.) that performance on metaphonological tasks reflects the combinatory influences of a number of variables. For example, subjects 5 and 17 had very different profiles but still provided no explanations. Subject 5 had relatively (to the overall group) high scores on the variables nonverbal cognition and speech production; average performance on the variables phonological awareness and auditory memory; lower speech perception scores and markedly low scores on the variable vocabulary. This might suggest that subject 5's limitation on the production of explanations lay in 'coding' phonological awareness into linguistic output. In contrast subject 17 had a very low performance, relative to the group, on the variables phonological awareness, vocabulary, nonverbal cognition, auditory memory and speech perception leading to the potential hypothesis that, for this subject, the limitation lay not in one specific area but in the generally reduced level of linguistic (including phonological) and cognitive processing.

There were similar individual differences in subjects who were able to give word and segment centred explanations. For example, subject 19 performed below the level of the group mean on all variables but still produced word centred explanations. This evidence further illustrates the need to consider an interactive view of the influence of contributing variables, rather than looking at skills in isolation.

Additional support for the potential value of an interactionist approach is provided by consideration of the form of the explanations. Whilst Donaldson and Elliot's (1990) system of analysis was difficult to apply within the context of a metaphonological task, many of the explanations had features which corresponded with Donaldson and Elliot's 'intentional mode' explanation, with the intention of the speaker corresponding to the reason for the item being judged correct or incorrect.

Donaldson and Elliot (1990) argue that the production of explanations in the intentional mode imposes both cognitive and linguistic demands on the child. The cognitive load comes from the need to make the distinction between the reason and the result. The linguistic demands arise because of the linguistic complexity of the semantic and syntactic constructions necessary to show that the underlying mismatch between form and meaning has been recognised. The findings reported in this thesis support Donaldson and Elliot's (1990) conclusion by providing additional evidence that children younger than five years old are able to produce such explanations, and therefore that they are able to understand the concept of intention, and to separate their analysis of meaning and form, processing the two simultaneously.

Donaldson and Elliot argue that one of the potential reasons that theorists such as Piaget (2.2.1.) believed that children could not perform such analyses (and therefore produce such explanations) until around the age of seven, was that the Piagetian tasks were experimental. Studies which allow children to apply their cognitive and linguistic skills to situations which have meaning for them potentially provide more reliable evidence of, for example, metaphonological skills. The data from Experiment 2, showing that the ability to provide such explanations increases with age, supports the developmental trend found in the literature (2.3.2.5.).

The current findings indicate that children as young as four years of age are able to link linguistic processing (in terms of speech perception, internal phonological processing, semantic and syntactic processing) and cognitive processing (in terms of retention, accessing and analysis skills) to produce explicit descriptions of the mismatch between meaning and form in relation to the perception of the speaker's intentions. This single case study data is further support for the model of metaphonological processing that is beginning to emerge; children's ability to provide explanations of metaphonological phenomena depends not on absolute levels of processing in the implicated/contributing competencies, but on a subtle interaction of processing skills.

7.11. A SYNERGISTIC MODEL OF METAPHONOLOGICAL PROCESSING

The evidence presented in this analysis allows the development of a model of emerging phonological awareness which has a different emphasis from previously published frameworks (Bialystok, 1986; Karmiloff-Smith, 1986; Galambos and Goldin Meadow, 1990). The model proposed is a synergistic model of metaphonological processing which emphasises the coaction of influential variables (such as phonological memory, phonological processing and cognition) and environmental influences.

This chapter has presented evidence for this hypothesis from both group and single case data. The linear regression highlighted the contribution of three variables to metaphonological processing in five year old children; phonological memory, phonological processing, and cognition. Single case study data focusing on, for example, segmentation skills, highlighted the fact that children with very different individual profiles achieved similar levels of phonological awareness (7.9). The data gives support to the hypothesis that variables, such as phonological processing and memory, interact to facilitate the development of phonological awareness.

It is argued that the interrelated nature of the influence of different variables is due to the fact that there is more than one way to perform each metaphonological task with different children employing different combinations of processing strengths and skills. One child may have a greater capacity to access or manipulate less precise phonological representations whilst another may apply lower levels of cognitive control to a well organised system of precise phonological representations. In the case of subject 21 (see section 7.9.) we might hypothesise that it was the marked improvement in memory skills which allowed this child to develop her literacy skills.

Complementary evidence comes from the study of children's abilities to give explanations based on phonological structure (7.10.). Individual subjects performed very differently on this task despite having similar performance scores on such variables as speech perception and production, cognition and vocabulary. This evidence reinforces the contention that performance on metaphonological tasks is the result of the coaction of several influential variables.

A further influence is environmental factors such as family background, including informal exposure to literacy skills. This thesis has focused primarily on preschool children but, in the wider context, the notion of environmental influences could extend to schooling, particularly literacy training, and intervention such as speech and language therapy. In the preschool context, it can be argued that factors such as family background might act to influence the development of phonological awareness; additional parental input (in the form of practice on metaphonological and/or literacy based tasks) might help to support phonological and cognitive processing skills.

Whilst environmental influences would be expected to be important, the current study found only weak evidence that family background influences metaphonological processing with this relationship becoming more evident at the second testing. If, due to the developing nature of metaphonological skills, environmental influences become more important (7.8.) a study of older children would be expected to delineate this influence more closely (7.13.2.). The current study, due to its focus, provided more robust evidence about the nature of the variables which interact to influence emerging phonological awareness. However, the environmental influences, such as schooling or therapy, are of interest due to their influence on the development of the child's capacity to process information.

A model of emerging phonological awareness based on the co-operancy of influential variables fits within an information processing framework (2.2.2.). The notion that deficits in one process are solely responsible for observed performance levels is discredited. This is particularly true in the field of linguistic processing where it is rare for one aspect of cognitive or linguistic ability to be identified as the sole cause of language processing difficulties (Lahey and Bloom, 1994).

This thesis argues that phonological awareness is facilitated by the synergistic processing of variables such as phonological memory, phonological processing and cognition. The contributions of each of these variables are not absolute, but are part of the dynamic whole. One implication of this model is that it becomes less important to try to identify a single contributing variable as being central to metaphonological processing. The relative contribution of an individual variable will depend on many different factors such as processing skills in other domains, the age of the child, the area of metaphonological processing being tapped and the task demands. At any one point in time there will be a complex interplay of factors supporting phonological awareness. This synergy can be conceptualised within the paradigm of a limited capacity information processing system. It has been argued (Crystal, 1987) that a child has a fixed capacity and that if a particular aspect of processing requires additional resources these must be diverted from another area. Similarly, there is evidence of 'trade off' between levels of processing due to competing task demands (4.7.4.1.).

The finding that children who perform similarly well on a test of phonological awareness display marked variation in their individual profiles can be explained in terms of a synergistic model of metaphonological processing. Increased efficiency in processing in one area may allow the child to redirect processing resources to less able components. Thus, processing components may interact to allow the child to achieve success on a particular task. Increased speed and efficiency of processing will reflect increased maturity, but can also be seen as being related to environmental influences (2.2.2.) such as informal and formal literacy training and, in the therapeutic context, intervention.

It is interesting to speculate that a model of developing phonological awareness which stresses the interactive nature of the contribution of relevant variables might offer an alternative explanation for the contradictory findings reported by several studies of language impaired children. For example, Kahmi and Koenig (1985), Howell (1989) and Warrick and Rubin (1992) report studies in which the performance range of the language disordered subjects on tests of phonological awareness overlaps with that of the normally developing subjects; and in which the group performance of the language disordered children is not uniformly poor, but has islets of competence.

The suggestion has been made that these findings are related to differences in task demands (Magnusson, 1991; Warrick and Rubin, 1992) but an alternative hypothesis is that it is the individual variation in subjects' related processing skills which is important. For example, Howell (1989; 3.5.2. & 3.5.5.) proposes that a possible explanation for her findings might lie in the variation in the speech perception skills of her phonologically disordered group. It is possible to go further and to argue that it is not just the level of an individual contributing variable which is important, but the way in which it interacts with other such variables to facilitate the skill of phonological awareness. .

There is some possible support for this position from other studies of language disordered children (Leonard, 1986; Kahmi, 1987) which provide evidence that some language impaired children show an ability to compensate for linguistic (decoding and encoding) difficulties by producing a higher number of clarification requests (2.3.3.6.) than would normally be found. Such children could be argued to be demonstrating compensatory strategies based on underlying processing strengths. Further evidence for different routes to the same processing 'end' is provided by studies such as Cossu, Rossini and Marshall's (1994) study of a group of subjects with Down's syndrome who had learnt to read without developing metaphonological skills.

This thesis argues that the contradictory findings highlighted here may be explained by individual differences not just in individual variables but specifically the way that those abilities combine to support the entity 'phonological awareness'. The model of emerging phonological awareness proposed is one of synergistic interaction between contributing processing components. Such a model allows not only an explanation of the way in which individual variables influence phonological awareness but also has implications for the design of facilitation programmes (7.13.3.).

7.12. METHODOLOGICAL ISSUES

There are several methodological changes that could profitably be made if this study was to be repeated, or extended (see section 7.12.). These changes relate primarily to the design of the assessment battery, and to the subject group.

17.12.1. Testing of speech perception skills

First, in the light of the findings of the importance of speech perception skills, particularly for the younger subject group, more detailed testing of these skills is indicated. For example, the assessment procedure could be improved by the inclusion of a speech discrimination test which will, due to its task demands, be particularly sensitive to differences in auditory processing not detected by ABX designs (3.3.3. & 4.8.1.1.). Task demands could be manipulated by, for example, requiring children to discriminate between sequences of sounds rather than one feature (3.2.5.); by choosing test items such that maximum contrast is achieved (3.2.5.); by targeting contrasts to reflect those most commonly mispronounced at a particular age (3.2.8.); and/or by using nonword stimuli to avoid any influence of semantic cues (3.2.8.).

Further, there would be advantages in the computer generation and presentation of items within such a test to allow for the precise manipulation, and consistent production, of acoustic features (3.2.9.). Testing of speech perception within sound proof conditions would be of value for the same reasons. However, it has to be recognised that an demanding assessment battery which requires subjects to attend for repeated laboratory sessions is liable to affect the composition of the subject group due to self selection. Only some families would be prepared to co-operate in this form of study. These constraints might result in the very limitations a replication of this work should seek to avoid (see section 7.12.5.). Whilst testing in school settings may have disadvantages, the demands on parents/carers are less and consequently there is more likelihood of the sample selected at the outset remaining in the study.

7.12.2. Assessment of speed of accessing phonological codes

The second suggested improvement to the test battery involves the addition of a task similar to that used by Wagner, Torgesen, Laughon, Simmons and Rashotte (1993) (3.2.6.) to allow assessment of speed of accessing phonological codes. This alteration to the test procedure is prompted by the finding of the importance of the phonological processing skills that underpin metaphonological processing. Speed of access was found by Wagner et al (1993) to be a factor that was distinguishable, and distinct, from other phonological processing abilities. The equation generated by the linear regressions carried out on the data from the current study (5.9. & 6.12.) indicated that for the four year old subjects the equations accounted for 23% of the variation in metaphonological scores, and for the five year olds, 47%. Measurement of the additional phonological processing variable (speed of accessing phonological codes) not assessed in the current study, might allow an even higher percentage of the variation in metaphonological processing scores to be accounted for.

7.12.3. Assessment of general language processing skills

In the context of the second experiment a similar argument can be made for including a measure of vocabulary skills, as an indication of general language processing skills. This variable was assessed in the first experiment but was dropped from the second experiment due to time constraints (6.8.1.). However, it is arguable that, as with nonverbal cognitive skills, a more general language processing ability might have accounted for variation in metaphonological scores at five years old, despite not apparently having been particularly influential at four years. Inclusion of this variable in the regression analysis might have allowed a higher proportion of the variance in metaphonological scores to be accounted for.

7.12.4. Assessment of written language processing skills

Within a study focusing on subjects as young as four years old, a reading test is perhaps most useful to exclude subjects with precocious reading skills; the primary purpose of its use in the current investigation. In order to obtain a more sensitive estimate of age appropriate written language processing skills a redesign of this study could include a measure of grapheme/phoneme correspondence skills (letter/sound knowledge) Such tests have been shown to be indicative both of the influence of segmental skills on literacy (1.3.3.2.) and of changes in metaphonological processing (1.6.2.1.).

7.12.5. Subject group

A further methodological change, which could have improved the experiments reported in this thesis, is the inclusion of a subject group which would more accurately reflect the range of family backgrounds in the population as a whole. One of the difficulties within such studies is the necessity for the population to be drawn from the schools which the Regional Education Department selects as appropriate. Whilst representation can be made to the Department regarding the need for the schools selected to include children from a range of social backgrounds, the eventual choice is likely to be based on many factors of which population characteristics are only one. Thus, it seems that within the context of a study such as the current work (as opposed to research commissioned by, for example, an Education Department) there might inevitably be some methodological limitations with regard to the composition of the subject group.

7.12.6. Nature of the individual subtests of the phonological awareness test

The phonological awareness test included four subtests; acceptability judgement (pa1), phoneme identification (pa2), rime judgement (pa3) and feature analysis (pa4) (4.7.). together these subtests contributed to a phonological awareness score the distribution of which was close to the normal distribution on testing at four, and at five, years old .

However, the individual subtests (with the exception of pa4 tested at four years old and pa3 tested at five years old) did not have normally distributed scores for this group of subjects. A replication of this study might profitable include more items within each subtest to increase the chances of a normal distribution of scores. This would allow the relationship of the individual subtests to the other variables, and change over time on these subtests, to be explored using parametric statistical techniques.

The only drawback to this methodological alteration might be the resulting size of the overall phonological awareness test. However, the test could be completed over two sessions on adjacent days, reducing the effect of subject fatigue and ensuring reliable measurement of performance.

7.13. FUTURE STUDIES

7.13.1. A study of the nature and correlates of phonological awareness in three year old children

The final suggested improvement to the design of this study *can* be implemented; an extension of the study to include three year old children. The aim of this amendment is to allow a more accurate profiling of phonological processing skills. Previous studies have been influenced by assumptions about the age at which children can co-operate in the assessments of metaphonological processing. Few studies of phonological awareness (with the notable exception of Chaney, 1992) have focused on children with a mean age as young as the population studied in the first experiment of the current thesis.

The four year old children's performance on the metaphonological test was such that it is possible to argue that the test could be used with children of 3;06 or even 3;00 years old. The four year old children's mean score on the Test of Phonological Awareness was 70.39 (out of 100) with the range being 49-86. These findings suggest that there is sufficient leeway such that younger children would not display floor effects on the overall test. The advantage of testing children younger than four lies in the fact that their speech production skills are much less well developed. Phonological process analysis (4.8.2.1.) of a sample of the speech of a child aged, for example, 3;03 would be highly likely to display evidence of the simplifying processes that are operating on the speech output. By the age of four the indications of the nature of the underlying phonological representations that can be gained from analysis of speech output are far more subtle.

The evidence from three year old children would provide a more detailed picture of the maturity of the underlying system of phonological representations, allowing a better estimate of the resulting variation in metaphonological processing. The advantage of a test of phonological awareness such as that employed in the current study, which includes metaphonological abilities other than phoneme awareness, is that the test is appropriate for children younger than 4;00. If the study was repeated with a group of three year old children, phonological process analysis could be used as an additional way of profiling phonological processing skills. The resulting data would allow a more accurate estimation of the interrelationship between metaphonological and phonological processing skills.

If the current study was replicated with children aged 3;00 and/or 3;06, it would allow exploration of the variables influencing metaphonological processing in three year old children. If this cohort of children was then reassessed at four years old, the proposed study would allow verification of the variables identified in the current study as influencing phonological awareness in four year old children. If the findings were similar to that reported in this thesis more confidence could be placed in the current findings. Evidence could also be gathered about the stability of metaphonological abilities between three and four years old; evidence which would be directly relevant to the planning of facilitation programmes (see section 7.13.). If different variables appear to underpin metaphonological processing at 3;00, than were identified at 4;00, these skills could be incorporated into a facilitation programme aimed specifically at the development of three year old children's awareness of the sound system of their language.

Finally, but equally importantly, retesting these three year old children one year later would allow identification of children who had developmental speech or language disorders. The data from the performance of these children at 3;00 could then be studied for evidence which might allow early identification of those children and/or provide indications for the potential content of remediation programmes. If evidence of the interrelationship between phonological awareness and phonological disorder is accepted (3.5.2.) then such a study would have important implications for the management of children with speech and language disorders.

7.13.2. A follow up study of the emerging literacy skills of the original subject group aged seven

A further fruitful area for future study would be the following up of the original cohort when the children are seven years old (plus or minus one month). At this age the children would be reading, and those of the sample who had reading difficulties could be identified.

It would then be possible to relate early metaphonological skills and related variables (measured at four years old) to later reading progress. Whilst other studies have followed children's progress for several years (see, for example, Bradley and Bryant, 1983) few, if any, have involved a subject group with a mean age as low as 4;00, and/or have followed progress in the absence of any metaphonological facilitation programme.

Such a study might also offer the opportunity to study the changes in metaphonological processing over time. One potential issue for such a design would be that seven year old children might operate at ceiling on three out of the four subtests of the measure of phonological awareness used in the current study. This is the reason that previous studies (for example, Bryant, MacLean and Bradley, 1990) have used different measures of phonological awareness at different ages. However, it could be argued that performance on the subtest pa2 (phoneme identification), from the current test of phonological awareness, would still reveal differences in seven year old children's phoneme segmentation skills. Thus, at least, performance on one subtest could be followed up at a third testing.

In addition, it would be of value to employ additional tests of metaphonological processing in order to tap phonological awareness in the seven year old children. Several studies have focused on the early school years (for example, Magnusson, 1991; Carlisle and Normanbhoy, 1993; Wagner, Torgesen, Laughon, Simmons and Rashotte (1993) and a review of these could form the basis for a decision about additional metaphonological tests to be included in the assessment battery.

Extending the current study to allow testing of the children in later years would provide valuable evidence about the stability, or otherwise, of phonological awareness over time; and about the possible early identification of children at risk of reading impairment. Finally, the nature of the correlates of metaphonological processing in seven year old children will add to knowledge of the concept of 'phonological awareness'; of developmental changes that occur in this skill over time; and to the understanding of the way in which literacy skills can be facilitated.

7.13.3. Implications for future facilitation studies

The correlation between the scores on the phonological awareness test at first and second testing was high (6.18.1), suggesting that there was a high degree of stability in individual performance, over time, on this variable. Further, a multivariate analysis (6.19.) to evaluate which of the variables tested at four predicted phonological awareness at five indicated that a significant proportion of this variance is accounted for by an equation including phonological awareness (PA) scores at four years old, level of paternal education (PED) and vocabulary skills (BPVS) at four years old; with phonological awareness making the most important contribution.

It is interesting that speech perception scores at four years old (which predicted a significant proportion of the variance in phonological awareness at four) did not predict phonological awareness at five. However, this is perhaps not surprising given the argument presented in this thesis; that metaphonological abilities at four, and at five, years old are qualitatively different. The basis of the relationship between speech perception and abilities termed metaphonological at four years old can be hypothesised to be grounded in the level at which the child can engage in reflection on the nature of the sound system; being able to detect and judge match and mismatch. However, by five years old the child's metaphonological abilities have developed to allow manipulation and analysis of phonological units.

An important finding is that, despite the qualitative differences in metaphonological abilities at four, and at five, years old, phonological awareness at four years old (as measured by the phonological awareness test) predicts phonological awareness at five. This evidence, together with the results of the correlational analyses, allows the argument that phonological awareness is a skill which changes in its nature, but which is stable with regard to the relative abilities of the subject group.

The finding that level of parental education can predict phonological awareness at five years old reinforces the notion that other environmental factors, such as facilitation programmes, may be able to influence the development of phonological awareness, providing some justification for the instigation of these programmes. However, level of paternal education may influence phonological awareness through other factors such as intellectual, or linguistic abilities. This argument is supported by the fact that the third variable in the regression equation is vocabulary scores; that is, general linguistic skills at four predict phonological awareness at five years old.

Interestingly, the results from the linear regression which explores the relationship between performance on the individual subtests of the phonological awareness test at five years old, and the remaining variables tested at four (6.21.) indicates that performance on subtest pa3 at five is predicted by performance on the vocabulary test at four years old and by family background.

In section 1.7 the relevance of stability was discussed in terms of the provision, and content, of facilitation programmes designed to develop metaphonological skills in children. These studies have tended to focus on the influence of such programmes on children's later reading and spelling skills, although Howell and Dean (1994) discuss the facilitation of metaphonological skills in the context of a remediation programme for phonological disorder.

Stability was discussed in section 1.7. in terms of both its positive and negative influences on the outcome of a facilitation programme. The hypothesised positive influence stems from the suggestion that, if phonological awareness is not a stable entity, the value of enhancing it is decreased because such changes may, in any case, occur with age. Further, it would make selection of appropriate candidates for the programme very difficult. However, stability may also be seen as a contraindication (Blachman, 1994a) in that a highly stable skill may prove difficult to influence.

Whilst evidence of the effectiveness of previous facilitation studies has been generally positive (see for example, Bradley and Bryant, 1983; Lundberg, Frost and Petersen, 1988;

Lie, 1991; Byrne and Fielding-Barnsley, 1992; 1.6.) an analysis of their findings, and discussion, suggests that maximum effect is achieved by tailoring the content of the programme to

- the variables known to influence the development of phonological processing, for example, phonological memory (see Naslund and Schneider, 1991; 6.3.)

or to

- variables known to influence literacy skills, for example letter sound correspondence (See Bradley and Bryant, 1983; Lie, 1991; Torgesen, Wagner and Rashotte, 1994; 1.6.2.1.)

or to

- factors known to be influential in the case of individual subjects (see, for example Blachman, 1994a; 1.6.2.1.)

It seems logical that a facilitation programme which aims to develop relevant skills, and which takes account of the performance of individual children in these areas, will have a more positive effect and will potentially be more economic in terms of time spent on the training. The findings of the regression analyses carried out in the current study allow further illumination of the variables involved in metaphonological processing and therefore of the potential content of metaphonological facilitation programmes for children of different ages.

The finding that, at four years old, a significant proportion of the variation in phonological awareness scores is due to performance on the test of speech perception argues that facilitation programmes for four year old children should include a significant proportion of perceptual activities. However, the regression analysis carried out on the data from the five year old children indicates elements which could begin to be included in the programme in order to build the skills needed for the focus of metaphonological awareness to shift from a sensitivity to the perceptual characteristics of the item to an ability to retain, access and analyse. Thus, skills such as phonological memory and phonological processing could be introduced to the syllabus of the facilitation programme. Further support for the early inclusion of these variables comes from the bivariate and multivariate analyses which support the role of auditory memory skills in metaphonological processing at four years old (7.6).

This concept of the content of a metaphonological facilitation programme moves away from a focus on phoneme processing tasks to that of a programme targeted to a specific range of phonological processing (input and output) activities. Such an emphasis would be particularly relevant if, as suggested in section 7.11, the relationship between phonological awareness and contributory variables is not absolute but synergistic. If different combinations of variables can interact to achieve the same outcome in terms of performance on a phonological awareness task, then the aim of the facilitation programme might be broadened. It might be possible to develop the strengths in a child's processing capacities in order to allow compensation for areas of weakness, in addition to, or instead of, focusing on those problem areas. Alternatively, the aim of the facilitation programme could be conceptualised as giving the child specific practice in the integration of cognitive, linguistic and phonological processing which is required for the metaphonological processing.

7.14. SUMMARY OF THE FINDINGS OF THE INVESTIGATION

- This thesis builds a model of metaphonological processing that hypothesises interaction between phonological processing (within several domains including perception, production and memory) and cognitive processing.

- Developing phonological awareness is related to an emerging, perceptually based, system of internal phonological representations.

- Developing phonological awareness requires maturation of memory skills to allow information to be retained in short term memory, and to be coded for longer term storage.

- Developing phonological awareness requires cognitive skills which allow analysis of perceptual stimuli, and of stored representations.

- Developing phonological awareness utilises production competencies through processes such as recoding of information for storage and analysis.

- While there appears to be a link between phonological awareness and family background, particularly parental education, this is probably due to the influence of a third factor (potentially nonverbal cognition).

- Phonological processing capacities operate interactively to allow the emergence of phonological awareness, with strengths in one processing component being able to (some extent to) compensate for weakness in another. This interaction allows children with individual profiles to achieve similar levels of phonological awareness.

- Phonological awareness is a skill which changes in nature between the ages of four and five, but which is stable with regard to the relative abilities of the subject group.

- Performance on the phonological awareness test at five years old is closely correlated to performance on the same test at four years old.

- Performance on the phonological awareness test at five years old is predicted by a regression equation comprising the variables phonological awareness and vocabulary skills tested at four years old, and the level of paternal education.

- Facilitation programmes could be improved by a shift in content to a focus on the variables known to contribute to phonological processing at different ages.

7.15. CONCLUSION

This chapter provides strong support for the hypothesis that developing phonological awareness depends on a changing pattern of linguistic and cognitive skills. Evidence from the bivariate and multivariate analyses suggests that at four years old perceptual abilities are influential in promoting phonological awareness. However, by five years old the variables which underpin metaphonological processing abilities are phonological memory, phonological processing and cognitive skills.

Evidence from performance on the individual subtests of the phonological awareness test supports this conclusion. At four, children appear to perform best on tasks involving perception and judgement of phonological structure whereas by five years old the child can perform metaphonological tasks which require them to hold items in memory, to access a relatively intact system of internal representations and to manipulate these representations.

The hypothesis proposed in this thesis is that emerging metaphonological skills are influenced by both linguistic (specifically phonological) and cognitive processing. As well as being dependent on analytical and deductive reasoning, awareness of the structure of language requires the ability to hold phonological features in memory, the ability to access phonological codes, and a sufficiently intact system of phonological features/codes.

However, the central argument of this thesis is that the contribution of each of these areas is not absolute. That is, similar levels of phonological awareness can be achieved by different processing combinations of these central influences. Evidence from case study data is presented to illustrate the argument that subjects with different levels of ability in individual areas of phonological and cognitive processing can achieve similar levels of metaphonological performance. The hypothesis proposed is that influential variables interact to support emerging metaphonological skills, and a synergistic model of emerging phonological awareness is proposed.

This hypothesis allows a reinterpretation of findings from previous studies; for example, the range of metaphonological skills shown by phonologically disordered children (Howell, 1989; Magnusson, 1991). One explanation of these findings might be that some children with less than intact systems of internal phonological representations (which result in the diagnosed pronunciation problem) may be able to compensate for this constraint due to the strength of their cognitive and/or memory skills.

In addition to offering an explanation for some of the contradictory findings reported in the literature, this hypothesis about the nature of metaphonological processing suggests that individual differences in underlying abilities might be compensated for by developing strengths in related processing fields. The value of facilitation programmes is strengthened by the finding that whilst the nature of phonological awareness changes over time, there is a strong relationship between metaphonological abilities evident at four years old and those emerging at five years. If these hypotheses are correct, the implication is that children with poor phonological awareness could be identified as early as four years old with some confidence that, without intervention, that their metaphonological skills would be unlikely to change over the next year. Further, facilitation programmes (for phonological disorder or reading difficulties) can be individually tailored to develop the strengths, and minimise the weaknesses, of individual children.

APPENDIX 1

ADMINISTRATION

Appendix 1

Queen Margaret College

EDINBURGH

Principal Donald Leach, BSc, FIMA, CPhys, MInstP, CEng, MBCS

Clerwood Terrace • Edinburgh • EH12 8TS

Telephone 031 317 3000
Fax No 031 317 3256

Speech Pathology & Therapy
Head of Department
Professor M A McGovern
MA, DipCSLT, MCSLT

Dear

I am a qualified speech therapist and am carrying out a study of the extent to which children can 'think' about language. The findings will help us to learn more about the best way to teach language and reading.

I hope to study 60 children who are within one month of their fourth birthday. I would like to see each child for approximately three half-hour, or four twenty minute sessions. All information will be treated in the strictest confidence and there will be no individual identification of any child.

The sessions could take place in your home or I can arrange appointments at Queen Margaret College . I would require a quiet room with a power point so that I can record ______________________'s responses to the sound games.

As your child will reach his/her fourth birthday during the next year, I would be very grateful for the opportunity to include him/her in the study.. I need to select a balanced group of children and to do this would require some information from you about your current occupation(s) and school leaving age(s).

If you are agreeable to my contacting you further, I would be grateful if you could fill in and sign the attached slip and return it in the pre-paid envelope.

Yours sincerely

ELIZABETH C DEAN MEd BA MCSLT
Clinical Research Fellow

....

For the attention of Elizabeth Dean, Dept of Speech Pathology & Therapy

Child's name ....

Date of birth ....

Address..

Contact phone number ....

I am agreeable to .... taking part in Ms Dean's study of speech sound awareness.

Signed .... Date.................................

Father's current/last occupation*...

Mother's current/last occupation* ....

Age at which father left full-time education ....

Age at which mother left full-time education ....

Languages other than English spoken in the home ....

* If a housewife/husband please put last paid employment.

STUDY1.LTR

Appendix 1

March 1992

<u>SPEECH THERAPY CLINIC</u>
DIRECT DIAL 031 317 3684
(SECRETARY) 031 317 3688

Dear

I am a qualified speech and language therapist with many years of experience of working in the community. I am currently undertaking a study concerned with the development of young children's ability to think about, and reflect on, speech sounds. I am interested by the published research evidence that links this language skill with later reading ability.

The name of your school was given to me by Lothian Region Education Department after I obtained ethical approval. The research would involve my visiting your nursery class to assess around twenty-five children over a period of around 18 months. The children would be aged within one month of their fourth birthday and would be seen for 4 - 5 twenty minute, individual sessions each. (I would therefore require a quiet room, with a power point, in which to see the children).

I am aware of the many demands upon your time and I am grateful to you for considering this request to visit your school. I would welcome the opportunity to talk to you about the project and will contact you in about one week to hear your views.

Yours sincerely

Elizabeth C Dean
Clinical Research Fellow

Appendix 1

July 1992

SPEECH THERAPY CLINIC
DIRECT DIAL 031 317 3684
(SECRETARY) 031 317 3688

Dear

Thank you for agreeing to let take part in my project. As you know, I will be seeing the children when they are within one month of their fourth birthday.

I will contact you nearer this time to make final arrangements.

With best wishes.

Yours sincerely

Elizabeth C Dean
Clinical Research Fellow

ECD/PHD/THANKYES.LTR

Appendix 1

ECD\KRH\PHD\STUDY4.LTR

15 January 1993

Dear

Thank you for giving permission for me to see ____________________ in my study of child awareness of sounds.

Before I see ____________________ could I ask you to take five minutes to fill in a brief questionnaire? This will help me get an overall picture. Please return it to me in the prepaid envelope.

I am very grateful for your help.

Yours sincerely

Elizabeth C Dean
Clinical Research Fellow

Appendix 1

ECD\KRH\PHD\L393.1

11 March 1993

Dear

Thank you for agreeing to let take part in my project. As you know, I will be seeing the children when they are within one month of their fourth birthday.

I will let you know when I have finished seeing .

With best wishes

Yours sincerely

Elizabeth C Dean MEd BA RegMCSLT
Research Fellow

Appendix 1

July 1992

SPEECH THERAPY CLINIC
DIRECT DIAL 031 317 3684
(SECRETARY) 031 317 3688

Dear

Thank you for replying to our recent letter regarding my study of speech sound awareness. Currently I have enough children in group and so may not need to see him/her. However I would be grateful if I could keep your reply on file and may contact you again if the position changes.

With best wishes.

Yours sincerely

Elizabeth C Dean
Clinical Research Fellow

NB - this letter was sent to children who did not meet the selection criteria in terms of age.

ECD/PHD/THANKENU.LTR

Appendix 1

ECD\KRH\PHD\STUDY3.LTR

Dear

I am sorry that you did not feel it was appropriate for your child to take part in my study of children's ability to think about sounds.

If it would help for me to answer any questions about the project, I would be very pleased to talk to you.

Yours sincerely

Elizabeth C Dean
Clinical Research Fellow

TEXT BOUND
INTO
THE SPINE

Appendix 1

DRAFT

PHD\KRH\L1293.5

Dear

As you may remember, you agreed to let take part in my study of children's ability to think about speech sounds.

It is now almost one year since I saw and I would like to visit her again to follow up my first investigation. I will be seeing each child for a maximum of 2 half hour sessions during school time (if agreed with individual Head Teachers and teachers). I will let you know when I have finished seeing .

Once again, thank you for your help. Do contact me if you would like any further information.

Yours sincerely

Elizabeth C Dean MEd BA RegMCSLT
Research Fellow

Appendix 1

PHD\KRH\L1293.1

December 1993

Dear

One year ago you kindly brought to take part in my study of children's ability to think about speech sounds.

As I mentioned in my last letter, I need to follow up the children one year later and I would like to see for a maximum of 2 more sessions. I will ring you in the New Year to arrange a convenient time.

Once again, I am most grateful for your interest and help.

Yours sincerely

Elizabeth C Dean MEd BA RegMCSLT
Research Fellow

Appendix 1

PHD\KRH\0294.1

1 February 1994

Dear

I have now finished seeing all the children from Primary School who are in my study.

I am most grateful to you and to all your staff who helped me find rooms and arrange for me to see the children. Special thanks, of course, go to Miss M and Mrs L.

I will write to all the parents concerned to thank them for allowing their children to take part.

With best wishes.

Yours sincerely

Elizabeth C Dean MEd BA RegMCSLT
Research Fellow

Appendix 1

PHD\LETTERS\010194.2

20 January 1994

Dear

Thank you for letting help with my study of childrens' ability to think about sounds. I am hoping to complete the study this September and to write a confidential report.

I have been very grateful for all your co-operation.

Best wishes.

Yours sincerely

Elizabeth C Dean MEd BA RegMCSLT
Research Fellow

APPENDIX 2

DATA COLLECTION

QUEEN MARGARET COLLEGE

DEPARTMENT OF SPEECH PATHOLOGY & THERAPY

ELIZABETH C DEAN - PhD STUDY

CHECKLIST

SUBJECT: DOB:

CODE: SCHOOL:

ASSESSMENT	COMPLETED (DATE)	SCORE
Hearing Questionnaire		
pa 1		/30
pa 2		/30
pa 3		/20
pa 4		/20
PA Total		/100
EAT		RS= SS=
WPPSI/non-verbal		
WPPSI sentences		
Auditory Discrimination		/20
Schonell		
CNRep		/40

Appendix 2

SUBTEST PA 1: ACCEPTABILITY JUDGEMENTS

Name: .... Age: .... Date of Test: ....

School: .... Class: ....

Item (Code)	Score	Explanation	Correction
Training tree	G/s	....	....
bɪk	g/S	....	....
brick	G/s	....	....
ti	g/S	....	....
Subtest tɑt	g/S	....	....
tɪəz	g/S	....	....
spoon	G/s	....	....
tɪ	g/S	....	....

Appendix 2

cup	G/s	....	....
		....	
		....	
gate	G/s	....	....
		....	
		....	
wɪŋ	g/S	....	....
		....	
		....	
pəɪd	g/S	....	....
		....	
		....	
snake	G/s	....	....
		....	
		....	
dəʊt	g/S	....	....
		....	
		....	
cat	G/s	....	....
		....	
		....	
stairs	G/s	....	....
		....	
		....	
pun	g/S	....	....
		....	
		....	
key	G/s	....	....
		....	
		....	

Appendix 2

tʌp	g/s	....	....
		....	
		....	
dɜːt	g/s	....	....
		....	
		....	
swing	G/s	....	....
		....	
		....	
spade	G/s	....	....
		....	
		....	
nɜɪk	g/s	....	....
		....	
		....	
goat	G/s	....	....
		....	
		....	

TOTAL ________

TARGET ________

NON TARGET ________

Appendix 2

SUBTEST PA 2: PHONEME IDENTIFICATION

Name: .... DOB: .... Age: ....

Date of Test: ....School: .... Class: ....

				Score	
1.	sock	(s)	Y/n	______	1
2.	boat	(t)	Y/n	______	2
3.	meat	(f)	y/N	______	3
4.	gun	(g)	Y/n	______	4
5.	bus	(s)	Y/n	______	5
6.	fork	(p)	y/N	______	6
7.	cup	(p)	Y/n	______	7
8.	book	(θ)	y/N	______	8
9.	fish	(f)	Y/n	______	9
10.	boot	(g)	y/N	______	10
11.	ball	(ʃ)	y/N	______	11
12.	bath	(θ)	Y/n	______	12
13.	bag	(g)	Y/n	______	13
14.	shute	(ʃ)	Y/n	______	14
15.	peg	(z)	y/N	______	15
16.	farm	(b)	y/N	______	16
17.	fan	(z)	y/N	______	17
18.	dog	(d)	Y/n	______	18
19.	doll	(t)	y/N	______	19
20.	peas	(z)	Y/n	______	20
21.	juice	(t)	y/N	______	21
22.	bone	(s)	y/N	______	22
23.	ship	(g)	y/N	______	23
24.	pen	(p)	Y/n	______	24
25.	pan	(k)	y/N	______	25
26.	van	(v)	Y/n	______	26
27.	duck	(k)	Y/n	______	27
28.	cake	(s)	y/N	______	28
29.	house	(b)	y/N	______	29
30.	cat	(k)	Y/n	______	30

TARGET TOTAL	/15	NON TARGET TOTAL	/15
Cvc	/8	Cvc	/8
cvC	/7	cvC	/7

TOTAL /30

Appendix 2

SUBTEST PA 2 ANALYSIS SHEET

Name: .... DOB: .... Age: ....

Date of Test: .... School: .... Class: ......

STOPS

Cvc				cvC			
No	Item		Score	No	Item		Score
4	gun	(g)	____	27	duck	(k)	____
18	dog	(d)	____	2	boat	(t)	____
24	pen	(p)	____	7	cup	(p)	____
30	cat	(k)	____	13	bag	(g)	____
	TOTAL		____ 4		TOTAL		____ 4

FRICATIVES

Cvc				cvC			
NO	Item		Score	No	Item		Score
1	sock	(s)	____	5	bus	(s)	____
9	fish	(f)	____	12	bath	(θ)	____
14	shute	(ʃ)	____	20	peas	(z)	____
26	van	(v)	____				
	TOTAL		____ 4		TOTAL		____ 3

NON TARGET: Cvc				NON TARGET: cvC			
	Item		Score	No	Item		Score
6	fork	(p)	____	22	bone	(s)	____
11	ball	(ʃ)	____	10	boot	(g)	____
28	cake	(s)	____	17	fan	(z)	____
23	ship	(g)	____	21	juice	(t)	____
15	peg	(z)	____	29	house	(b)	____
3	meat	(f)	____	25	pan	(k)	____
16	farm	(b)	____	8	book	(θ)	____
19	doll	(t)	____				
TOTAL			____ 8		TOTAL		____ 7

SUBTEST2.FRM

SUBTEST PA 3: RIME JUDGEMENTS

Name: .... DOB: .... Age ....

Date of Test: .... School: .... Class: ....

	Item	Code	Answer	Score
Training:				
	said	r,w	Y/n	....
	cap	d,w	y/N	....
	led	r,w	Y/n	....
Subtest:				
	head	r,w	Y/n	....
	ring	d,w	y/N	....
	mɛd	r,nw	Y/n	....
	vɪŋ	d,nw	y/N	....
	bed	r,w	Y/n	....
	red	r,w	Y/n	....
	kɛd	r,nw	Y/n	....
	zɔ	d,nw	y/N	....
	house	d,w	y/N	....
	boat	d,w	y/N	....
	fed	r,w	Y/n	....
	wɪt	d,nw	y/N	....
	fat	d,w	y/N	....
	pɛd	r,nw	Y/n	....
	foɒt	d,nw	y/N	....
	gɛd	r,nw	Y/n	....
	shed	r,w	Y/n	....
	boən	d,nw	y/N	....
	door	d,w	y/N	....
	ɪɛd	r,nw	Y/n	....
			TOTAL	______ 20

TOTAL r: /10 TOTAL d: /10

w = ______ w = ______

nw = ______ nw = ______

KEY
r = rime
d = non rime
w = word
nw = nonword

ECD/PHD/SUBTEST3.FRM

SUBTEST 4: FEATURE ANALYSIS

Name: .... DOB: .... Age: ....

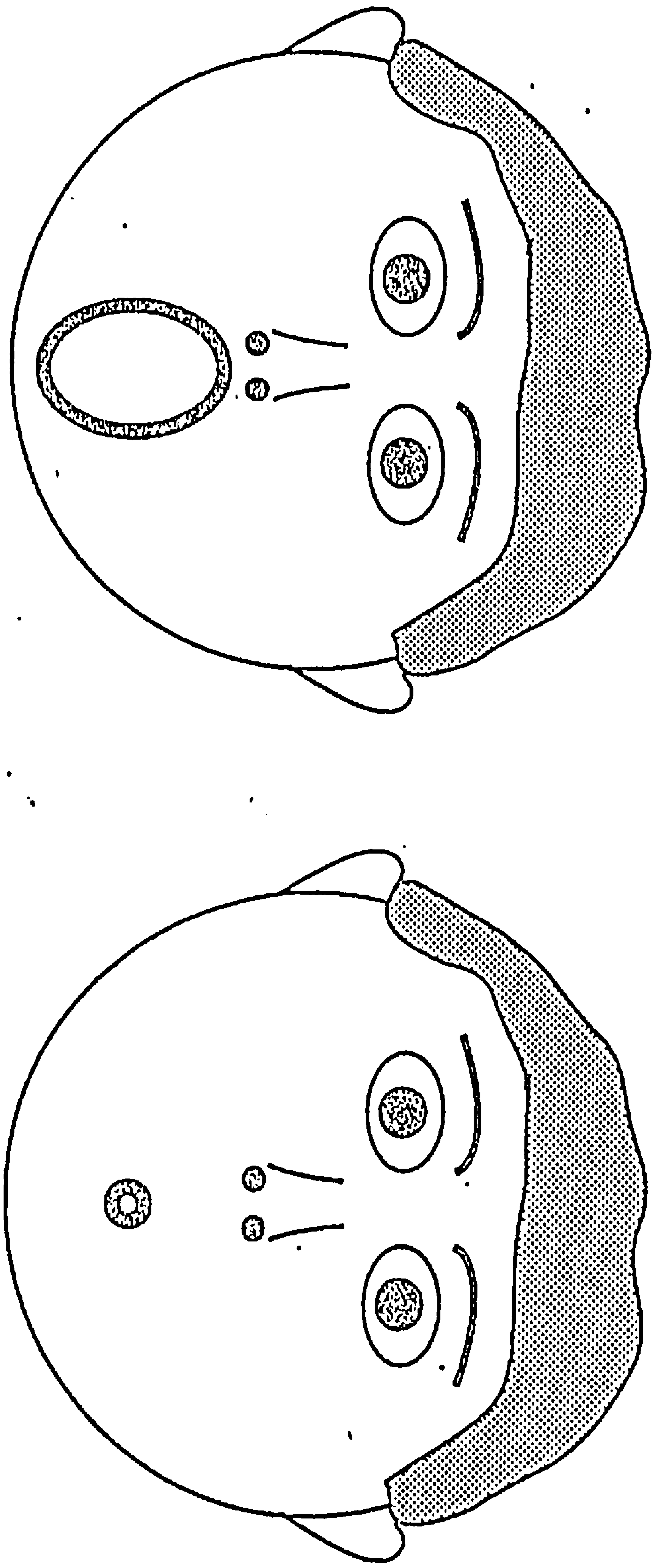
Date of Test: .... School: .... Class: ....

	Items	Response	Score
Training:			
	s	vl/v	....
	v	vl/v	....
	z	vl/v	....
	s	vl/v	....
	z	vl/v	....
Subtest:			
	b	vl/v	....
	t	vl/v	....
	k	vl/v	....
	b	vl/v	....
	p	vl/v	....
	g	vl/v	....
	g	vl/v	....
	t	vl/v	....
	p	vl/v	....
	g	vl/v	....
	t	vl/v	....
	d	vl/v	....
	b	vl/v	....
	k	vl/v	....
	k	vl/v	....
	d	vl/v	....
	d	vl/v	....
	p	vl/v	....
	b	vl/v	....
	t	vl/v	....

SCORE: ________
20

ECD\PHD\SUBTEST4.FRM

Appendix 2



AUDITORY DISCRIMINATION

Name .... Age .... Date of Test ....

School .... Class ....

Examples	dough	wing	key	zoo
	thin	pan	late	ship

1	tie	pie	....	11	zip	dip	....
2	din	bin	....	12	coat	goat	....
3	fin	thin	....	13	pan	man	....
4	sip	zip	....	14	zip	sip	....
5	wing	ring	....	15	pie	tie	....
6	man	pan	....	16	pin	bin	....
7	dip	zip	....	17	sea	tea	....
8	bin	din	....	18	thin	fin	....
9	goat	coat	....	19	bin	pin	....
10	ring	wing	....	20	tea	sea	....

TOTAL /20

COMMENTS

Appendix 2

Hearing Questionnaire

Child's name .... Date of Birth ....

Please answer the following questions by circling YES or NO. There is space under each question for you to add any comments, to ask us questions or to give any examples if you wish.

1. Does your child turn round if you say her/his name when s/he can't see you? YES NO

2. Does s/he come to find out what's happening or turn round if s/he hears sounds like the cups rattling or sweet or biscuit papers? YES NO

3. Does s/he let you know if the telephone or door bell rings? YES NO

4. Can s/he find objects when asked to? eg."Where's your teddy?" or "Find your socks." YES NO

5. Does s/he respond differently to different sounds? For example, does s/he cry at loud noises or look happy if someone laughs or sings? YES NO

6. Does s/he copy any sounds? For example, will s/he make animal or car noises? YES NO

7. Does s/he copy other people talking? YES NO

8. Will s/he fetch things for you when you ask, even if you don't look at or point to what you want? YES NO

9. Does s/he like being read to? YES NO

10. Can s/he point to pictures in a book if you ask her/him? YES NO

11. Does s/he like listening to songs or nursery rhymes? YES NO

12. Can s/he say or sing any songs or rhymes? YES NO

13. Can s/he let you know when the ice cream van comes, or s/he hears other noises outside? YES NO

14. Does s/he have any favourite TV adverts? YES NO

15. Does s/he copy any TV adverts? YES NO

16. Can s/he find you when you call from another room? YES NO

17. Have you noticed that you frequently have to repeat what you say to him/her? YES NO

18. Does s/he like listening to music or story tapes? YES NO

19. Have you ever seen her/him move nearer to people or look closely at them when they start talking? YES NO

20. Does s/he ever turn up the TV louder than you find comfortable? YES NO

21. Has s/he ever had sore ears? YES NO

Thank you for completing the questionnaire.

APPENDIX 3

EXPERIMENT 1

Raw Data

Appendix 3

Subject	SX	pa1	pa1a	pa2	pa3	pa3-nw	pa3-w	pa4	PA total	EAT	BPVS	WPPSI	Blocks	AM	AD	FB	PL	AUD	MED	PED	EXP
1	2	28	18	16	10	5	5	16	70	61	37	102	13	11	17	2	1	1	0	0	1
2	2	28	19	20	18	9	9	20	86	56	50	80	10	17	19	2	1	0	0	0	1
3	1	30	20	11	9	9	8	20	70	46	46	119	26	29	18	1	0	0	1	1	1
4	1	30	20	14	17	5	4	19	80	62	53	81	10	15	18	1	1	1	1	1	0
5	2	26	19	17	11	4	7	16	70	58	20	116	20	13	15	1	1	0	1	1	0
6	2	26	19	15	10	5	5	12	63	57	36	99	17	12	12	3	1	0	0	0	1
7	2	27	18	15	11	5	6	12	65	62	38	66	10	11	17	2	0	0	1	1	0
8	1	23	17	15	10	5	5	10	58	28	19	26	0	6	13	3	1	0	0	0	0
9	2	11	11	15	15	5	5	17	58	55	36	81	5	10	14	2	1	1	0	0	0
10	1	30	20	15	16	8	8	19	80	58	33	78	7	17	17	3	1	1	1	1	1
11	2	26	18	21	12	8	9	20	79	48	31	69	6	15	14	1	1	1	0	1	1
12	2	30	20	16	10	5	5	20	76	58	46	95	14	13	20	1	1	0	1	1	0
13	2	28	19	15	10	6	4	18	71	63	43	85	4	13	20	1	0	0	1	1	1
14	1	28	19	15	10	5	5	11	64	51	35	87	10	13	15	1	0	1	1	1	1
15	2	23	18	15	9	4	5	11	58	35	30	80	11	11	12	2	1	1	0	1	1
16	1	30	20	15	10	5	5	14	69	41	27	64	6	14	17	2	1	0	0	0	0
17	1	10	10	15	10	4	6	14	49	45	25	77	11	9	15	2	1	0	0	0	0
18	1	26	19	15	10	5	5	19	70	52	26	46	2	9	18	2	1	0	0	0	0
19	1	27	19	15	14	6	8	20	76	62	46	86	8	16	18	2	0	1	1	0	1
20	2	28	18	15	13	5	8	17	73	59	43	106	13	14	15	3	1	0	0	0	1
21	2	30	20	15	19	10	9	20	84	58	50	99	13	12	18	2	1	1	1	0	1
22	1	14	12	15	10	5	5	14	53	58	35	61	3	12	15	2	0	1	1	1	0
23	1	30	20	15	16	8	8	19	80	57	45	90	12	13	15	1	1	0	1	1	0
24	2	29	20	25	10	5	5	19	83	67	43	97	10	11	17	2	0	0	0	1	1
25	1	29	20	15	10	4	6	20	74	51	28	70	6	11	15	3	0	0	0	0	0
26	1	27	18	15	8	5	3	17	67	47	46	78	5	8	18	3	0	1	0	0	1
27	2	29	20	19	8	5	3	15	71	64	41	125	27	13	18	2	0		0	1	1
28	1	22	17	15	14	7	7	13	64	57	41	102	16	11	16	1	1	0	1	1	0
29	2	30	20	15	13	5	8	16	74	58	53	134	21	12	18	1	0	1	1	1	1
30	2	29	19	15	11	6	5	20	75	45	43	77	9	14	17	1	1	0	1	1	0
31	2	30	20	16	13	6	7	12	71	62	39	104	11	17	18	1	0	1	1	1	0
32	2	26	18	20	16	6	10	11	73	60	23	109	12	11	17	2	0	1	1	0	1
33	2	27	20	15	10	5	5	16	68	58	38	129	18	17	17	2	0	0	0	0	1
34	1	28	19	12	10	4	6	14	64	38	16	55	0	6	10	2	1	1	1	0	0
35	1	30	20	15	10	5	5	13	78	65	43	51	6	10	19	1	0	1	1	1	1
36	1	30	20	15	10	5	5	14	69	53	45	80	11	16	17	1	1		1	1	1
37	2	25	17	15	10	5	5	16	66	54	43	89	8	12	10	1	0	0	1	1	1
38	2	30	20	15	10	5	5	18	73	60	45	107	5	21	17	1	0	1	1	1	1
39	2	30	20	15	10	5	5	20	75	48	69	130	19	25	18	1	0		1	1	1
40	2	24	17	15	10	5	5	8	57	63	39	74	9	13	17	2	1		0	0	1
41	1	22	16	15	10	6	4	17	64	46	51	91	17	13	17	2	0	1	0	1	1
42	1	30	20	15	16	9	7	19	80	51	61	108	10	14	17	2	1	1	1	0	1
43	1	30	20	15	11	6	5	15	71	58	52	79	11	18	17	1	1		1	1	1
44	2	30	20	15	19	10	9	19	83	60	55	106	9	20	20	1	1	0	1	1	1
45	2	26	18	15	11	6	5	19	70	59	37	96	7	24	18	1	0	0	1	1	1
46	1	30	20	15	10	5	5	11	66	60	46	122	14	15	16	1	1		1	1	1

APPENDIX 4

EXPERIMENT 1

Univariate Analyses

Appendix 4

Summary Statistics

Speech Perception (AD)

Valid cases: 46.0 Missing cases: .0 Percent missing: .0

Mean	16.4348	Std Err	.3428	Min	10.0000	Skewness	-1.0776
Median	17.0000	Variance	5.4068	Max	20.0000	S E Skew	.3501
5% Trim	16.5797	Std Dev	2.3252	Range	10.0000	Kurtosis	1.2024
95% CI for Mean (15.7443, 17.1253)				IQR	3.0000	S E Kurt	.6876

```
Frequency    Stem & Leaf
   2.00 Extremes    (10.0)
   2.00      12 . 00
   1.00      13 . 0
   2.00      14 . 00
   7.00      15 . 0000000
   2.00      16 . 00
  14.00      17 . 00000000000000
  11.00      18 . 00000000000
   2.00      19 . 00
   3.00      20 . 000
Stem width:     1.00
Each leaf:      1 case(s)
```

Speech Perception (ADLOG)

Valid cases: 46.0 Missing cases: .0 Percent missing: .0

Mean	2.7881	Std Err	.0232	Min	2.3026	Skewness	-1.5369
Median	2.8332	Variance	.0248	Max	2.9957	S E Skew	.3501
5% Trim	2.8023	Std Dev	.1575	Range	.6931	Kurtosis	2.5574
95% CI for Mean (2.7414, 2.8349)				IQR	.1823	S E Kurt	.6876

Auditory Memory (AM)

Valid cases: 46.0 Missing cases: .0 Percent missing: .0

Mean	13.8478	Std Err	.6703	Min	6.0000	Skewness	1.2429
Median	13.0000	Variance	20.6652	Max	29.0000	S E Skew	.3501
5% Trim	13.5604	Std Dev	4.5459	Range	23.0000	Kurtosis	2.4031
95% CI for Mean (12.4979, 15.1978)				IQR	5.0000	S E Kurt	.6876

```
Frequency    Stem & Leaf
   5.00       0 . 66899
  26.00       1 * 00111111122222333333334444
  10.00       1 . 5556677778
   2.00       2 * 01
   3.00 Extremes    (24), (25), (29)
Stem width:    10.00
Each leaf:     1 case(s)
```

Appendix 4

Auditory Memory (AMLOG)

Valid cases:	46.0	Missing cases:	.0	Percent missing:	.0		
Mean	2.5792	Std Err	.0465	Min	1.7918	Skewness	-.0334
Median	2.5649	Variance	.0996	Max	3.3673	S E Skew	.3501
5% Trim	2.5821	Std Dev	.3157	Range	1.5755	Kurtosis	1.0916
95% CI for Mean	(2.4855, 2.6730)			IQR	.3747	S E Kurt	.6876

Vocabulary (BPVS)

Valid cases:	46.0	Missing cases:	.0	Percent missing:	.0		
Mean	40.1522	Std Err	1.6151	Min	16.0000	Skewness	-.0518
Median	42.0000	Variance	119.9986	Max	69.0000	S E Skew	.3501
5% Trim	40.0845	Std Dev	10.9544	Range	53.0000	Kurtosis	.3228
95% CI for Mean	(36.8991, 43.4052)			IQR	11.5000	S E Kurt	.6876

```
Frequency   Stem & Leaf
   1.00 Extremes   (16)
   1.00      1 . 9
   2.00      2 * 03
   4.00      2 . 5678
   3.00      3 * 013
  10.00      3 . 5566778899
   8.00      4 * 11333333
   8.00      4 . 55566666
   6.00      5 * 001233
   1.00      5 . 5
   1.00      6 * 1
   1.00 Extremes   (69)
Stem width:   10.00
Each leaf:    1 case(s)
```

Vocabulary (BPVSLOG)

Valid cases:	46.0	Missing cases:	.0	Percent missing:	.0		
Mean	3.6510	Std Err	.0450	Min	2.7726	Skewness	-.9461
Median	3.7374	Variance	.0933	Max	4.2341	S E Skew	.3501
5% Trim	3.6662	Std Dev	.3054	Range	1.4615	Kurtosis	.9312
95% CI for Mean	(3.5603, 3.7417)			IQR	.2880	S E Kurt	.6876

Speech Production (EAT)

Valid cases:	46.0	Missing cases:	.0	Percent missing:	.0		
Mean	54.6522	Std Err	1.2231	Min	28.0000	Skewness	-1.2232
Median	58.0000	Variance	68.8097	Max	67.0000	S E Skew	.3501
5% Trim	55.2754	Std Dev	8.2952	Range	39.0000	Kurtosis	1.4674
95% CI for Mean	(52.1888, 57.1155)			IQR	9.7500	S E Kurt	.6876

Appendix 4

Frequency	Stem &	Leaf
2.00	Extremes	(28), (35)
1.00	3 .	8
1.00	4 *	1
7.00	4 .	5566788
6.00	5 *	111234
15.00	5 .	567778888888899
12.00	6 *	000012222334
2.00	6 .	57

Stem width: 10.00
Each leaf: 1 case(s)

Speech Production (EATLOG)

Valid cases:	46.0	Missing cases:	.0	Percent missing:	.0		
Mean	3.9876	Std Err	.0256	Min	3.3322	Skewness	-1.7781
Median	4.0604	Variance	.0301	Max	4.2047	S E Skew	.3501
5% Trim	4.0054	Std Dev	.1735	Range	.8725	Kurtosis	3.8568
95% CI for Mean	(3.9361, 4.0391)			IQR	.1777	S E Kurt	.6876

Non-verbal intellectual skills (WIPPSI)

Valid cases:	46.0	Missing cases:	.0	Percent missing:	.0		
Mean	89.2609	Std Err	3.4240	Min	26.0000	Skewness	-.2345
Median	88.0000	Variance	539.3082	Max	134.0000	S E Skew	.3501
5% Trim	89.7585	Std Dev	23.2230	Range	108.0000	Kurtosis	.1802
95% CI for Mean	(82.3645, 96.1573)			IQR	29.0000	S E Kurt	.6876

Frequency	Stem &	Leaf
1.00	Extremes	(26)
1.00	4 .	6
2.00	5 .	15
4.00	6 .	1469
7.00	7 .	0477889
9.00	8 .	000115679
7.00	9 .	0156799
8.00	10 .	22466789
2.00	11 .	69
3.00	12 .	259
2.00	13 .	04

Stem width: 10.00
Each leaf: 1 case(s)

Non-verbal intellectual skills (WIPPSILOG)

Valid cases:	46.0	Missing cases:	.0	Percent missing:	.0		
Mean	4.4518	Std Err	.0449	Min	3.2581	Skewness	-1.4921
Median	4.4773	Variance	.0926	Max	4.8978	S E Skew	.3501
5% Trim	4.4756	Std Dev	.3043	Range	1.6397	Kurtosis	4.1728
95% CI for Mean	(4.3614, 4.5421)			IQR	.3196	S E Kurt	.6876

Appendix 4

Phonological awareness (PA)

Valid cases: 46.0 Missing cases: .0 Percent missing: .0

Mean	70.3913	Std Err	1.2255	Min	49.0000	Skewness	-.3776
Median	70.5000	Variance	69.0879	Max	86.0000	S E Skew	.3501
5% Trim	70.6280	Std Dev	8.3119	Range	37.0000	Kurtosis	.0114
95% CI for Mean (67.9230, 72.8596)				IQR	11.2500	S E Kurt	.6876

```
Frequency   Stem & Leaf
  1.00      4 . 9
  1.00      5 * 3
  4.00      5 . 7888
  5.00      6 * 34444
  7.00      6 . 5667899
 14.00      7 * 00000111133344
  6.00      7 . 556689
  7.00      8 * 0000334
  1.00      8 . 6
```

Phonological awareness (PALOG)

Valid cases: 46.0 Missing cases: .0 Percent missing: .0

Mean	4.2469	Std Err	.0181	Min	3.8918	Skewness	-.7243
Median	4.2556	Variance	.0151	Max	4.4543	S E Skew	.3501
5% Trim	4.2529	Std Dev	.1228	Range	.5625	Kurtosis	.6058
95% CI for Mean (4.2104, 4.2834)				IQR	.1602	S E Kurt	.6876

Phonological awareness: Subtest 1 (pa1)

Valid cases: 46.0 Missing cases: .0 Percent missing: .0

Mean	26.7826	Std Err	.6908	Min	10.0000	Skewness	-2.3680
Median	28.0000	Variance	21.9517	Max	30.0000	S E Skew	.3501
5% Trim	27.4831	Std Dev	4.6853	Range	20.0000	Kurtosis	5.8284
95% CI for Mean (25.3913, 28.1740)				IQR	4.0000	S E Kurt	.6876

```
Frequency   Stem & Leaf
  3.00 Extremes   (10.0), (11.0), (14.0)
  2.00     22 . 00
  2.00     23 . 00
  1.00     24 . 0
  1.00     25 . 0
  6.00     26 . 000000
  4.00     27 . 0000
  6.00     28 . 000000
  4.00     29 . 0000
 17.00     30 . 00000000000000000
Stem width:   1.00
Each leaf:    1 case(s)
```

Subtest 1 (pa1log)

Valid cases: 46.0 Missing cases: .0 Percent missing: .0

Mean	3.2653	Std Err	.0352	Min	2.3026	Skewness	-3.0055
Median	3.3322	Variance	.0569	Max	3.4012	S E Skew	.3501
5% Trim	3.3065	Std Dev	.2386	Range	1.0986	Kurtosis	9.2274
95% CI for Mean (3.1945, 3.3362)				IQR	.1431	S E Kurt	.6876

Phonological awareness: Subtest 2 (pa2)

Valid cases: 46.0 Missing cases: .0 Percent missing: .0

Mean	15.5870	Std Err	.3254	Min	11.0000	Skewness	2.2780
Median	15.0000	Variance	4.8700	Max	25.0000	S E Skew	.3501
5% Trim	15.4058	Std Dev	2.2068	Range	14.0000	Kurtosis	7.7382
95% CI for Mean	(14.9316, 16.2423)			IQR	.0000	S E Kurt	.6876

Frequency Stem & Leaf
3.00 Extremes (11), (12), (14)
34.00 1 f 5555555555555555555555555555555555
9.00 Extremes (16), (17), (19), (20), (21), (25)
Stem width: 10.00
Each leaf: 1 case(s)

Subtest 2 (pa2log)

Valid cases:	46.0	Missing cases:	.0	Percent missing:	.0		
Mean	2.7380	Std Err	.0188	Min	2.3979	Skewness	1.4148
Median	2.7081	Variance	.0163	Max	3.2189	S E Skew	.3501
5% Trim	2.7321	Std Dev	.1277	Range	.8210	Kurtosis	5.4577
95% CI for Mean	(2.7000, 2.7759)			IQR	.0000	S E Kurt	.6876

Phonological awareness: Subtest 3 (pa3)

Valid cases:	46.0	Missing cases:	.0	Percent missing:	.0		
Mean	11.7391	Std Err	.4301	Min	8.0000	Skewness	1.1856
Median	10.0000	Variance	8.5082	Max	19.0000	S E Skew	.3501
5% Trim	11.5435	Std Dev	2.9169	Range	11.0000	Kurtosis	.3177
95% CI for Mean	(10.8729, 12.6053)			IQR	3.2500	S E Kurt	.6876

Frequency Stem & Leaf
2.00 8 . 00
2.00 9 . 00
22.00 10 . 0000000000000000000000
5.00 11 . 00000
1.00 12 . 0
3.00 13 . 000
2.00 14 . 00
1.00 15 . 0
4.00 16 . 0000
1.00 17 . 0
3.00 Extremes (18.0), (19.0)
Stem width: 1.00
Each leaf: 1 case(s)

Subtest 3 (pa3log)

Valid cases:	46.0	Missing cases:	.0	Percent missing:	.0		
Mean	2.4363	Std Err	.0334	Min	2.0794	Skewness	.8848
Median	2.3026	Variance	.0513	Max	2.9444	S E Skew	.3501
5% Trim	2.4274	Std Dev	.2266	Range	.8650	Kurtosis	-.2479
95% CI for Mean	(2.3690, 2.5036)			IQR	.2809	S E Kurt	.6876

Appendix 4

Phonological awareness: Subtest 4 (pa4)

Valid cases:	46.0	Missing cases:	.0	Percent missing:	.0		
Mean	16.0870	Std Err	.4991	Min	8.0000	Skewness	-.5022
Median	16.5000	Variance	11.4589	Max	20.0000	S E Skew	.3501
5% Trim	16.2488	Std Dev	3.3851	Range	12.0000	Kurtosis	-.8592
95% CI for Mean (15.0817, 17.0922)				IQR	5.2500	S E Kurt	.6876

Frequency	Stem & Leaf
1.00	0 . 8
15.00	1 * 011112223344444
21.00	1 . 556666677778899999999
9.00	2 * 000000000

Stem width: 10.00
Each leaf: 1 case(s)

Subtest 4 (pa4log)

Valid cases:	46.0	Missing cases:	.0	Percent missing:	.0		
Mean	2.7535	Std Err	.0341	Min	2.0794	Skewness	-.8773
Median	2.8029	Variance	.0534	Max	2.9957	S E Skew	.3501
5% Trim	2.7698	Std Dev	.2312	Range	.9163	Kurtosis	.1078
95% CI for Mean (2.6849, 2.8222)				IQR	.3239	S E Kurt	.6876

Ability to provide word/phoneme level explanations (EXP)

Valid cases:	46.0	Missing cases:	.0	Percent missing:	.0		
Mean	.6522	Std Err	.0710	Min	.0000	Skewness	-.6608
Median	1.0000	Variance	.2319	Max	1.0000	S E Skew	.3501
5% Trim	.6691	Std Dev	.4815	Range	1.0000	Kurtosis	-1.6366
95% CI for Mean (.5092, .7952)				IQR	1.0000	S E Kurt	.6876

Appendix 4
Experiment 1 Subtest pa1: Explanations

N	NON SPECIFIC EXP: unrel	NON SPECIFIC EXP: speech rel	MEANING CENTERED EXP	WORD CENTERED EXP	SEGMENT CENTERED EXPLANATION	NOTES
1	just because			cos its not x+	cos it was a ++ not a x+	cos she done it the first time
	cos did			cos she said x+		
2				she said x+	because this is a ++ and she called it a x+,	
				she said x+ and its not	because I can see its a ++ and she said x+	
3				cos its ++	no, not x+, ++ you silly girl	
				its really ++		
4			that's a thing to eat x+ ('date')	because its ++	because x+ isn't right, it should be ++	
				because x+ is stupid, what's a x+ anyway	its a s-s-s-snake	
				because x+ doesn't make sense		
5				it was x+		
				it was xx		
6	-					
7	just did			no you silly, ++		
	no you silly lady, silly dumpling					
8		cos me said it		cos her said x+	x+, I call it x+	
				cos me knew her said x+		
9				she said xx		
10				cos she said x+ ('tea') - eat my tea	cos she said x+ instead of ++	
				because she said x+	cos it was x+ ('date'), date's a food thing	
11	-					
12	-					
13	just did			cos they're ++		why does the girl get it right the first time and then wrong?
	a wee bit			x+ said		
				cos she said x+		
14				cos she should have called it ++		
16				cos they're ++		she didn't get it right last time
				cos she didn't say ++		
				cos its ++ and she didn't say ++		
18		just heard		no she said x+	she said x+ instead of ++	
				xal	cos she went xx ('nak') like naked	
19				cos it was ++		
				no it was ++		
20	cos					
	cos I always know					
21				cos she didn't say ++		she got it right last time
22				cos that is a ++		
				she had to say ++		
				says ++		
				cos I just say ++		
23	cos I did		cos I can recognise the picture	cos they're ++	they're not x+, they're ++	
24	well it might just be that			well, its meant to be ++	because its x+ or something	
				no, ++	because its ++	
				because its maybe, because I think its really meant to be ++		
25	because that's easy		it opens so its ++ (tev)	because its ++		
			because its a thing you eat with (spoon)			
26			because its on the picture	because it was a ++ because I know		
				because its on the picture and its ++		
27				cos she said x-	cos she said x+ instead of ++	cos she said x+ instead of ++ but the last time she said +-
				cos you've got to say ++	cos she said x+ instead of +-	
					I had a x+ (date) on holiday	
28		because its not right, maybe she didn't remember what that one was		cos she should have said ++	cos she said ++ not x-, ++	
					cos its not x+ its ++	
					because its not a x+ (wing) thats what birds have, its a ++	
					because it was like x-	
					I thought it was x- she said	
30			cos we've got a ++ at home	cos its a ++		
				because her didn't say ++		

Appendix 4
Experiment 1 Subtest pa1: Explanations (cont)

31				because it sounded like x+		
				because its ++		
				because she said x-		
				because she should have said ++		
33			because look what that one is	cos they're ++	she just said x+ but they're ++	its a ++ she got that one right first time
				no its a ++	its a ++, it was nearly the same but it wasn't ++	
				its a ++, I know it	he said x+ cos he didn't say ++	
34	and cos she, cos I did			cos she didn't say ++		
	its a funny one			cos its ++		
	cos she didn't					
35				cos she said x+	no that's not a x+, she said x+ when it was a ++	
				no they're ++	cos she said ++, no, what did she say (asked for replay) she said x- I can't say it	
				no she said x+		
				x+, x+!		
36				because she's supposed to say ++	cos she said x- and she should have said ++	
				cos ++		
37				no she went ++	because she went x+ and its a ++	
				cos its a ++	because they're ++ and she said these were ++	
				x-? she went x-	thats not x+ its a ++	
					x+? because it was ++	
					x+? she went	
					did she say x- or x-	
					cos its a ++ and she said x- but she nearly said x- didn't she	
38				no she said x+	no, she said x+, she should have said ++, sort of tree to drink	
				she said x+ (wing) I listened properly and I've got one in my garden		
				cos they're ++		
				cos she said x-		
39				cos she said x+	x- instead of ++	
				x+ she said x+		
				x+		
40				because she should have said ++	because she said x+, she should have said ++	
				no ++		
				cos she said x-		
41				cos she said x+		
				she said x-		
				she called it a x-		
42	cos I did			cos it was ++		
43	I just did	because she said, I don't know		she said x+		
	I don't know			she thought it was x+ probably		
				x+?		
				cos she said x+		
				no she said x+		
				no she said x-		
44				because that's a ++	because that's a ++ and she said x+	
45					because she said x+ instead of ++	
	KEY					
	(++) correct pronunciation	correctly reproduced				
	(+-) correct pronunciation	incorrectly reproduced				
	(x+) mispronunciation	correctly reproduced				
	(x-) mispronunciation	incorrectly reproduced				

Appendix 4
Experiment 1 Subtest pa2: Segmentation skills

Subject	seg:name	seg:pic p+s	seg:pic p+v	notes
1				
2				
3				
4	1	1	0	
5				
6				
7				
8				
9	0	0	0	
10				
11	0			
12	1	0	1	
13	0	0	0	
14	0	0	0	
15	0	0	0	
16				
17	1	0	0	
18	0	0	0	
19	1	1	0	
20	0	0	0	
21	0	0	0	attempted to segment but not producing the correct phoneme
22	0	0	0	attempted to segment but not producing the correct phoneme
23	1	0	1	
24	1	0	1	
25	0	0	0	
26	1	0	0	
27	1	1	0	
28	0	0	0	
29	1	0	0	
30	1	1	0	
31	1	0	0	
32	0	0	0	
33	1	0	0	
34	0	0	0	
35	0	0	0	rhymed 'Alaistair palaistair'
36	1	0	1	
37	1	0	0	
38	1	0	0	
39	1	0	1	
40	0	0	0	
41	0	0	0	
42	0	0	0	
43	1	0	0	
44	1	1	0	
45	1	0	1	
46	0	0	0	? sound 'teddy'
sum	19	5	6	
9 not	asked			
Key				
p+s	phoneme	and schwa	vowel	
p+v	phoneme	and correct	vowel	

APPENDIX 5

EXPERIMENT 1

Bivariate Analyses: Differences between Means

Appendix 5

Differences between means: Anovas

Maternal Education

Variable WIPPLOG
By Variable MEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.2287	.2287	2.5554	.1171
Within Groups	44	3.9381	.0895		
Total	45	4.1668			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.6648	1	44	.419

Variable PALOG
By Variable MEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0542	.0542	3.8246	.0569
Within Groups	44	.6240	.0142		
Total	45	.6782			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
2.6220	1	44	.113

Variable EATLOG
By Variable MEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.1114	.1114	3.9396	.0534
Within Groups	44	1.2436	.0283		
Total	45	1.3550			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
6.1762	1	44	.017

Appendix 5

Variable BPVSLOG
By Variable MEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.3107	.3107	3.5170	.0674
Within Groups	44	3.8876	.0884		
Total	45	4.1983			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.0001	1	44	.992

Variable AMLOG
By Variable MEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.5408	.5408	6.0352	.0180
Within Groups	44	3.9429	.0896		
Total	45	4.4837			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.3401	1	44	.563

Variable ADLOG
By Variable MEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0368	.0368	1.4985	.2274
Within Groups	44	1.0799	.0245		
Total	45	1.1166			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.1709	1	44	.681

Paternal Education

Variable WIPPLOG
By Variable PEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.2584	.2584	2.9095	.0951
Within Groups	44	3.9084	.0888		
Total	45	4.1668			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
1.7154	1	44	.197

Appendix 5

Variable PALOG
By Variable PEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0183	.0183	1.2229	.2748
Within Groups	44	.6599	.0150		
Total	45	.6782			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
1.7399	1	44	.194

Variable EATLOG
By Variable PEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0694	.0694	2.3751	.1304
Within Groups	44	1.2856	.0292		
Total	45	1.3550			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
1.7259	1	44	.196

Variable BPVSLOG
By Variable PEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.4944	.4944	5.8726	.0196
Within Groups	44	3.7039	.0842		
Total	45	4.1983			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
6.5953	1	44	.014

Variable AMLOG
By Variable PEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.8115	.8115	9.7230	.0032
Within Groups	44	3.6722	.0835		
Total	45	4.4837			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.2214	1	44	.640

Appendix 5

Variable ADLOG
By Variable PEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0292	.0292	1.1822	.2828
Within Groups	44	1.0874	.0247		
Total	45	1.1166			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.7055	1	44	.405

No range tests performed with fewer than three non-empty groups.

History of ear infections

Variable WIPPLOG
By Variable AUD

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0051	.0051	.0531	.8190
Within Groups	38	3.6716	.0966		
Total	39	3.6767			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.7345	1	38	.397

Variable PALOG
By Variable AUD

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0001	.0001	.0054	.9420
Within Groups	38	.6269	.0165		
Total	39	.6270			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.4200	1	38	.521

Variable EATLOG
By Variable AUD

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0015	.0015	.0461	.8311
Within Groups	38	1.2659	.0333		
Total	39	1.2674			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.0012	1	38	.973

Appendix 5

Variable BPVSLOG
By Variable AUD

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0331	.0331	.3458	.5600
Within Groups	38	3.6334	.0956		
Total	39	3.6665			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.0018	1	38	.967

Variable AMLOG
By Variable AUD

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0387	.0387	.3823	.5401
Within Groups	38	3.8460	.1012		
Total	39	3.8847			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.1298	1	38	.721

Variable ADLOG
By Variable AUD

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0003	.0003	.0099	.9212
Within Groups	38	1.0865	.0286		
Total	39	1.0868			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.0411	1	38	.840

No range tests performed with fewer than three non-empty groups.

Family background

Variable WIPPLOG
By Variable FB

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.1554	.1554	2.4364	.1268
Within Groups	38	2.4239	.0638		
Total	39	2.5793			

Levene Test for Homogeneity of Variances

Statistic df1 df2 2-tail Sig.

.7066	1	38	.406

Variable PALOG
By Variable FB

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0489	.0489	3.3271	.0760
Within Groups	38	.5584	.0147		
Total	39	.6073			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
8.1652	1	38	.007

Variable EATLOG
By Variable FB

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0211	.0211	.9361	.3394
Within Groups	38	.8560	.0225		
Total	39	.8771			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
5.7857	1	38	.021]

Variable BPVSLOG
By Variable FB

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.3555	.3555	4.2934	.0451
Within Groups	38	3.1468	.0828		
Total	39	3.5024			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
2.4765	1	38	.124

Variable AMLOG
By Variable FB

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.7521	.7521	10.5346	.0024
Within Groups	38	2.7128	.0714		
Total	39	3.4649			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.7586	1	38	.389

Appendix 5

Variable ADLOG
By Variable FB

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0147	.0147	.6039	.4419
Within Groups	38	.9275	.0244		
Total	39	.9423			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.0180	1	38	.894

No range tests performed with fewer than three non-empty groups.

Sex

Variable WIPPLOG
By Variable SX

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.7462	.7462	9.5987	.0034
Within Groups	44	3.4206	.0777		
Total	45	4.1668			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
3.0328	1	44	.089

Variable PALOG
By Variable SX

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0206	.0206	1.3791	.2466
Within Groups	44	.6576	.0149		
Total	45	.6782			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.6082	1	44	.440

Variable EATLOG
By Variable SX

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.1335	.1335	4.8108	.0336
Within Groups	44	1.2215	.0278		
Total	45	1.3550			

Appendix 5

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
2.3773	1	44	.130

Variable BPVSLOG
By Variable SX

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0669	.0669	.7130	.4030
Within Groups	44	4.1314	.0939		
Total	45	4.1983			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
3.9113	1	44	.054

Variable AMLOG
By Variable SX

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.1967	.1967	2.0189	.1624
Within Groups	44	4.2870	.0974		
Total	45	4.4837			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
1.8105	1	44	.185

Variable ADLOG
By Variable SX

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0036	.0036	.1421	.7080
Within Groups	44	1.1130	.0253		
Total	45	1.1166			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.8195	1	44	.370

No range tests performed with fewer than three non-empty groups.

Place in Family

Variable WIPPLOG
By Variable PL

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.2112	.2112	2.3494	.1325
Within Groups	44	3.9556	.0899		

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Total	45	4.1668

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.0016	1	44	.969

Variable PALOG
By Variable PL

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0001	.0001	.0075	.9315
Within Groups	44	.6781	.0154		
Total	45	.6782			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
4.1033	1	44	.049

Variable EATLOG
By Variable PL

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0866	.0866	3.0042	.0901
Within Groups	44	1.2684	.0288		
Total	45	1.3550			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
2.2545	1	44	.140

Variable BPVSLOG
By Variable PL

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.1486	.1486	1.6142	.2106
Within Groups	44	4.0497	.0920		
Total	45	4.1983			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
4.6611	1	44	.036

Variable AMLOG
By Variable PL

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.1615	.1615	1.6437	.2065
Within Groups	44	4.3222	.0982		
Total	45	4.4837			

Appendix 5

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.9143	1	44	.344

Variable ADLOG
By Variable PL

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0467	.0467	1.9186	.1730
Within Groups	44	1.0700	.0243		
Total	45	1.1166			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
1.6136	1	44	.211

No range tests performed with fewer than three non-empty groups.

Appendix 5

Ability to give word/phoneme level explanations

Variable ADLOG
By Variable EXP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0374	.0374	1.5233	.2237
Within Groups	44	1.0793	.0245		
Total	45	1.1166			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.1721	1	44	.680

Variable AMLOG
By Variable EXP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.7484	.7484	8.8159	.0048
Within Groups	44	3.7353	.0849		
Total	45	4.4837			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.0176	1	44	.895

Variable BPVSLOG
By Variable EXP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.9075	.9075	12.1340	.0011
Within Groups	44	3.2908	.0748		
Total	45	4.1983			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
7.9984	1	44	.007

Variable EATLOG
By Variable EXP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0894	.0894	3.1063	.0849
Within Groups	44	1.2657	.0288		
Total	45	1.3550			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
3.7060	1	44	.061

Appendix 5

Variable FB
By Variable EXP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0045	.0045	.0090	.9248
Within Groups	44	22.1042	.5024		
Total	45	22.1087			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.0417	1	44	.839

Variable MEDAGE
By Variable EXP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0065	.0065	.0262	.8721
Within Groups	44	10.9500	.2489		
Total	45	10.9565			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.1112	1	44	.740

Variable PALOG
By Variable EXP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0561	.0561	3.9684	.0526
Within Groups	44	.6221	.0141		
Total	45	.6782			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
2.3988	1	44	.129

Variable PEDAGE
By Variable EXP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0524	.0524	.2113	.6480
Within Groups	44	10.9042	.2478		
Total	45	10.9565			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.6345	1	44	.430

Appendix 5

Variable PL
By Variable EXP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.8377	.8377	3.5215	.0672
Within Groups	44	10.4667	.2379		
Total	45	11.3043			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
8.8371	1	44	.005

Variable SX
By Variable EXP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.6964	.6964	2.8592	.0979
Within Groups	44	10.7167	.2436		
Total	45	11.4130			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.0117	1	44	.914

Variable WIPPLOG
By Variable EXP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.7910	.7910	10.3093	.0025
Within Groups	44	3.3758	.0767		
Total	45	4.1668			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
2.6828	1	44	.109

Variable AUD
By Variable EXP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.7042	.7042	2.8863	.0975
Within Groups	38	9.2708	.2440		
Total	39	9.9750			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
1.7994	1	38	.188

No range tests performed with fewer than three non-empty groups.

Appendix 5

t-tests for independent samples of PA_TOTAL

Variable	Number of Cases	Mean	SD	SE of Mean
ADLOG				
PA_TOTAL 1	15	2.6559	.189	.049
PA_TOTAL 2	15	2.8675	.096	.025

Mean Difference = -.2116

Levene's Test for Equality of Variances: F= 7.406 P= .011

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	-3.86	28	.001	.055	(-.324, -.099)
Unequal	-3.86	20.79	.001	.055	(-.326, -.098)

Variable	Number of Cases	Mean	SD	SE of Mean
AMLOG				
PA_TOTAL 1	15	2.3476	.274	.071
PA_TOTAL 2	15	2.6765	.235	.061

Mean Difference = -.3289

Levene's Test for Equality of Variances: F= .315 P= .579

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	-3.53	28	.001	.093	(-.520, -.138)
Unequal	-3.53	27.38	.001	.093	(-.520, -.138)

Variable	Number of Cases	Mean	SD	SE of Mean
BPVSLOG				
PA_TOTAL 1	15	3.5320	.327	.084
PA_TOTAL 2	15	3.8530	.207	.054

Mean Difference = -.3210

Levene's Test for Equality of Variances: F= 1.746 P= .197

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	-3.21	28	.003	.100	(-.526, -.116)
Unequal	-3.21	23.70	.004	.100	(-.527, -.115)

Appendix 5

Variable	Number of Cases	Mean	SD	SE of Mean
EATLOG				
PA_TOTAL 1	15	3.8967	.233	.060
PA_TOTAL 2	15	4.0346	.116	.030

Mean Difference = -.1379

Levene's Test for Equality of Variances: F= 5.568 P= .026

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	-2.05	28	.050	.067	(-.276, .000)
Unequal	-2.05	20.51	.053	.067	(-.278, .002)

Variable	Number of Cases	Mean	SD	SE of Mean
FB				
PA_TOTAL 1	15	1.9333	.704	.182
PA_TOTAL 2	15	1.4667	.640	.165

Mean Difference = .4667

Levene's Test for Equality of Variances: F= .191 P= .665

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	1.90	28	.068	.246	(-.037, .970)
Unequal	1.90	27.75	.068	.246	(-.037, .970)

Variable	Number of Cases	Mean	SD	SE of Mean
PL				
PA_TOTAL 1	15	.6000	.507	.131
PA_TOTAL 2	15	.6667	.488	.126

Mean Difference = -.0667

Levene's Test for Equality of Variances: F= .516 P= .478

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	-.37	28	.716	.182	(-.439, .306)
Unequal	-.37	27.96	.716	.182	(-.439, .306)

Appendix 5

Variable	Number of Cases	Mean	SD	SE of Mean
SX				
PA_TOTAL 1	15	1.4000	.507	.131
PA_TOTAL 2	15	1.6000	.507	.131

Mean Difference = -.2000

Levene's Test for Equality of Variances: F= .000 P= 1.000

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-1.08	28	.289	.185	(-.579, .179)
Unequal	-1.08	28.00	.289	.185	(-.579, .179)

Variable	Number of Cases	Mean	SD	SE of Mean
WIPPLOG				
PA_TOTAL 1	15	4.3224	.357	.092
PA_TOTAL 2	15	4.4954	.244	.063

Mean Difference = -.1730

Levene's Test for Equality of Variances: F= .392 P= .536

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-1.55	28	.133	.112	(-.402, .056)
Unequal	-1.55	24.75	.134	.112	(-.403, .057)

Variable	Number of Cases	Mean	SD	SE of Mean
AUD				
PA_TOTAL 1	13	.5385	.519	.144
PA_TOTAL 2	14	.5714	.514	.137

Mean Difference = -.0330

Levene's Test for Equality of Variances: F= .099 P= .755

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-.17	25	.870	.199	(-.442, .377)
Unequal	-.17	24.81	.870	.199	(-.443, .377)

APPENDIX 6

EXPERIMENT 1

Bivariate Analyses: Correlations

Appendix 6

Correlations[1]

Pearson's Product moment Correlation Coefficients: interrelationships between main variables

	ADLOG	AMLOG	BPVSLOG	EATLOG	WIPPLOG
AMLOG	.4624 P= .001				
BPVSLOG	.5338 P= .000	.5848 P= .000			
EATLOG	.4895 P= .001	.3626 P= .013	.4586 P= .001		
WIPPLOG	.2767 P= .063	.5924 P= .000	.5218 P= .000	.5179 P= .000	
PALOG	.4817 P= .001	.4065 P= .005	.4492 P= .002	.3894 P= .007	.2915 P= .049

Interrelationship between WIPPSI and block scores (Experiment 1)

	WIPPLOG	BLLOG
WIPPLOG	1.0000 P= .	.7606 P= .000
BLLOG	.7606 P= .000	1.0000 P= .

(Coefficient / (Cases) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

[1]Variables names will be followed by the suffix lg, or log, to indicate transformed data

Appendix 6

Spearman Correlation Coefficients: interrelationships between variables

	ADLOG	AMLOG	BPVSLOG	EATLOG	FB	MEDAGE
AMLOG	.3723 Sig .011					
BPVSLOG	.5736 Sig .000	.4917 Sig .001				
EATLOG	.4428 Sig .002	.1707 Sig .257	.2291 Sig .126			
FB	-.2709 Sig .069	-.4468 Sig .002	-.3766 Sig .010	-.1638 Sig .277		
MEDAGE	.2524 Sig .091	.3459 Sig .019	.3446 Sig .019	.2357 Sig .115	-.6527 Sig .000	
PALOG	.5473 Sig .000	.4098 Sig .005	.5047 Sig .000	.3239 Sig .028	-.2171 Sig .147	.2807 Sig .059
PEDAGE	.1580 Sig .294	.3712 Sig .011	.2925 Sig .049	.2138 Sig .1	-.7262 Sig .000	.5437 Sig .000
WIPPLOG	.2174 Sig .147	.4246 Sig .003	.4325 Sig .003	.2983 Sig .044	-.2846 Sig .055	.2282 Sig .127
SX	.1262 Sig .403	.1356 Sig .369	.0296 Sig .845	.3497 Sig .017	-.0991 Sig .512	-.1089 Sig .471
PL	-.2739 Sig .066	-.0631 Sig .677	-.1125 Sig .456	-.2768 Sig .063	.0905 Sig .550	-.1641 Sig .276

	PALOG	PEDAGE	WIPPLOG	SX
PEDAGE	.1530 Sig .310			
WIPPLOG	.2351 Sig .116	.1930 Sig .199		
SX	.1663 Sig .269	.0700 Sig .644	.4078 Sig .005	
PL	.0116 Sig .939	-.2539 Sig .089	-.2296 Sig .125	-.0995 Sig .511

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

Appendix 6

Spearman Correlation Coefficients: relationship between Phonological Awareness Test and phonological awareness subtests

PA2LOG	-.0959 Sig .526			
PA3LOG	.1765 Sig .241	.1020 Sig .500		
PA4LOG	.3289 Sig .026	.0267 Sig .860	.2936 Sig .048	
PALOG	.6700 Sig .000	.2760 Sig .063	.5397 Sig .000	.7033 Sig .000
	PA1LOG	**PA2LOG**	**PA3LOG**	**PA4LOG**

(Coefficient / (Cases) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

Intercorrelations between individual subtests of the Phonological Awareness Test and other variables

	PA1LOG	**PA2LOG**	**PA3LOG**	**PA4LOG**
ADLOG	.4995 Sig .000	.0992 Sig .512	.1333 Sig .377	.4118 Sig .004
AMLOG	.5072 Sig.000	-.0290 Sig .848	.2482 Sig .096	.3851 Sig .008
AUD	.0842 Sig .605	-.0331 Sig .839	.1184 Sig .467	-.1358 Sig .403
BPVSLOG	.5566 Sig .000	-.1460 Sig .333	.2378 Sig .111	.4338 Sig .003
EATLOG	.2273 Sig .129	.3078 Sig .037	.2271 Sig .129	-.0676 Sig .655
PALOG	.6700 Sig .000	.2760 Sig .063	.5397 Sig .000	.7033 Sig .000
WIPPLOG	.2898 Sig .051	.1982 Sig .187	.1277 Sig .398	.1176 Sig .437
FB	-.3737 Sig .011	.0236 Sig .876	Sig .129 Sig .419	-.1167 Sig .440
MEDAGE	.4627 Sig .001	-.2564 Sig .085	.3488 Sig .017	.0846 Sig .576
PEDAGE	.2901 Sig .051	.0348 Sig .819	-.0445 Sig .769	.0406 Sig .789
PL	.0102 Sig .946	-.0385 Sig .799	.3154 Sig .033	-.0100 Sig .947
SX	-.0880 Sig .561	.5046 Sig .000	.1256 Sig .406	.0978 Sig .518

APPENDIX 7

EXPERIMENT 1

Multivariate Analysis

Appendix 7

Multiple regression[1]

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. PALOG

Block Number 1. Method: Stepwise Criteria PIN .0500 POUT .1000
PEDAGE PL SX WIPPLOG FB MEDAGE EATLOG BPVSLOG
AUD AMLOG ADLOG

Variable(s) Entered on Step Number
1.. ADLOG

Multiple R	.50868
R Square	.25876
Adjusted R Square	.23925
Standard Error	.11059

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	.16224	.16224
Residual	38	.46477	.01223

F = 13.26523 Signif F = .0008

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
ADLOG	.386383	.106086	.508682	1.000000	1.000	3.642
(Constant)	3.177036	.295443				10.753

----- in -----

Variable	Sig T
ADLOG	.0008
(Constant)	.0000

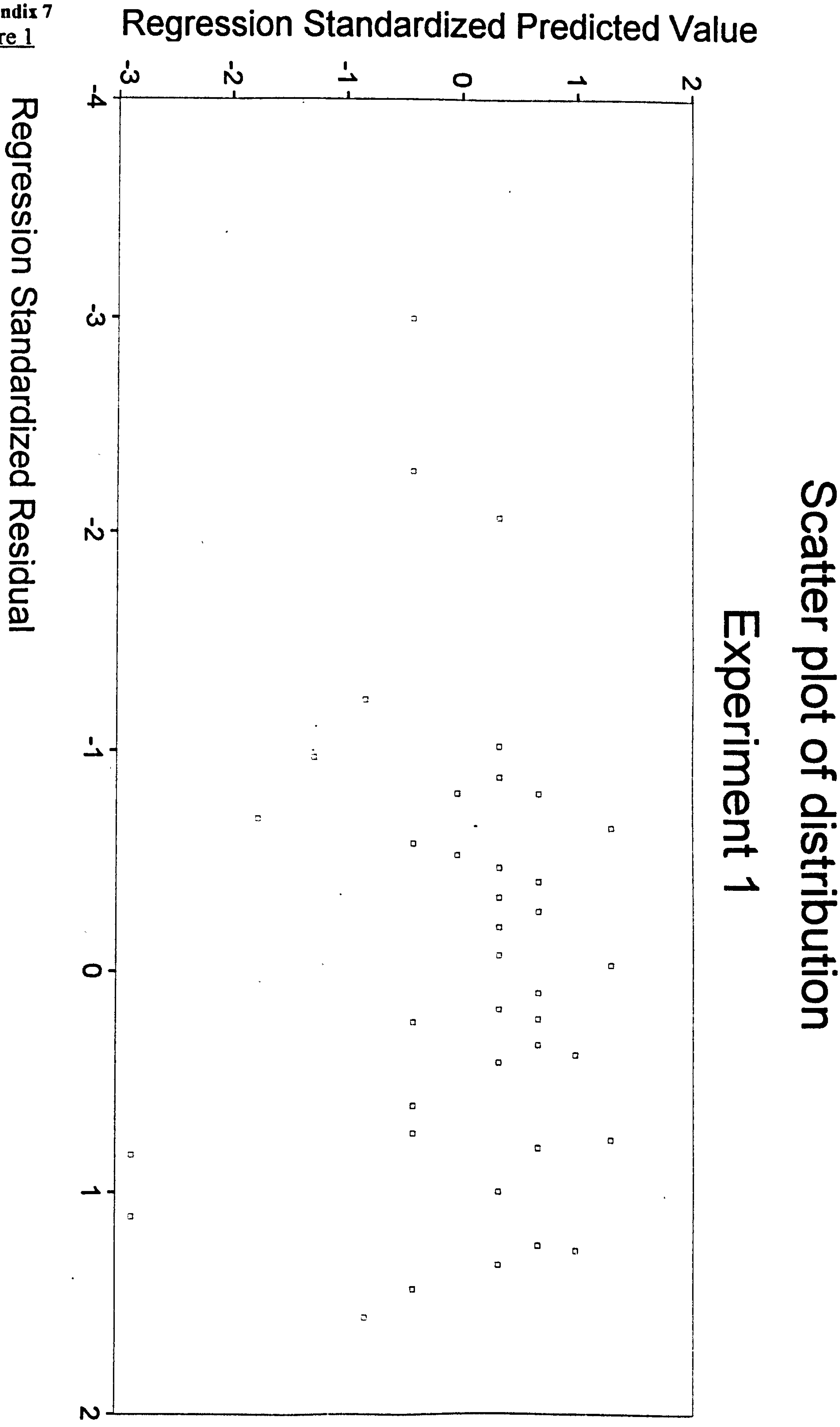
---------- Variables not in the Equation ----------

Variable	Beta In	Partial	Min Toler	T	Sig T
PEDAGE	.055544	.063832	.978930	.389	.6995
PL	.161421	.183566	.958572	1.136	.2633
SX	.183852	.213373	.998399	1.328	.1922
WIPPLOG	.173416	.194271	.930246	1.205	.2360
FB	-.104941	-.118327	.942393	-.725	.4731
MEDAGE	.169731	.193080	.959201	1.197	.2389
EATLOG	.284643	.286514	.751019	1.819	.0770
BPVSLOG	.295510	.290749	.717552	1.848	.0725
AUD	.020109	.023353	.999739	.142	.8878
AMLOG	.249656	.257816	.790493	1.623	.1131

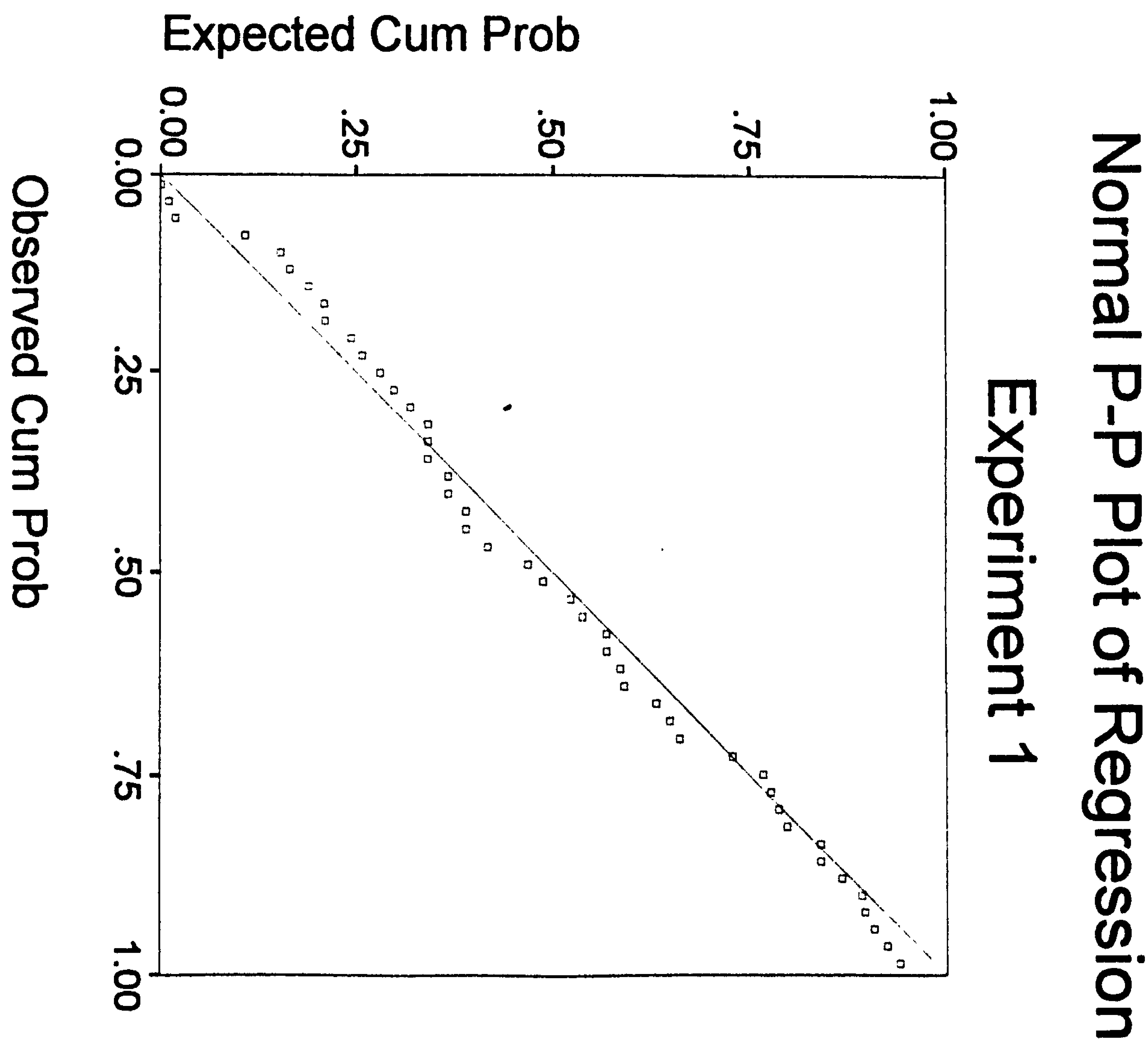
End Block Number 1 PIN = .050 Limits reached.

[11]Variables names will be followed by the suffix lg, or log, to indicate transformed data

Appendix 7
Figure 1



Appendix 7
Figure 2



Appendix 7
Stepwise Multiple Regression

Dependent variable: subtest pa1 (at four years old)
Independent variables: test scores at four years old.

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. PA1LOG

Block Number 1. Method: Stepwise Criteria PIN .0500 POUT .1000
ADLOG AMLOG AUD EATLOG BPVSLOG FB MED PED
PL SX WIPPLOG PA2LOG PA3LOG PA4LOG

End Block Number 1 PIN = .050 Limits reached.
No variables entered/removed for this block.

Appendix 7

Stepwise Multiple Regression **Dependent variable: subtest pa2 (at four years old)**
Independent variables: test scores at four years old.

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. PA2LOG

Block Number 1. Method: Stepwise Criteria PIN .0500 POUT .1000
ADLOG AMLOG AUD EATLOG BPVSLOG FB MED PED
PL SX WIPPLOG PA3LOG PA4LOG PA1LOG

Variable(s) Entered on Step Number
1.. SX

Multiple R	.41922
R Square	.17574
Adjusted R Square	.15150
Standard Error	.12217

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	.10820	.10820
Residual	34	.50749	.01493

F = 7.24935 Signif F = .0109

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
SX	.110331	.040978	.419219	1.000000	1.000	2.692
(Constant)	2.560076	.066916				38.258

----- in -----

Variable	Sig T
SX	.0109
(Constant)	.0000

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
ADLOG	.136093	.149897	.999951	1.000	.999951	.871	.3901
AMLOG	-.142604	-.151783	.933789	1.071	.933789	-.882	.3841
AUD	.001516	.001632	.954844	1.047	.954844	.009	.9926
EATLOG	.161278	.168874	.903734	1.107	.903734	.984	.3322
BPVSLOG	.027967	.030511	.981009	1.019	.981009	.175	.8619
FB	.103384	.110756	.946000	1.057	.946000	.640	.5265
MED	-.334167	-.367019	.994286	1.006	.994286	-2.267	.0301
PED	.034653	.037730	.977143	1.023	.977143	.217	.8296
PL	.022777	.025070	.998571	1.001	.998571	.144	.8863
WIPPLOG	-.163066	-.161637	.809865	1.235	.809865	-.941	.3536
PA3LOG	.095992	.105632	.998125	1.002	.998125	.610	.5459
PA4LOG	.141483	.155729	.998608	1.001	.998608	.906	.3717
PA1LOG	.016429	.018096	.999959	1.000	.999959	.104	.9178

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	SX
1	1.95258	1.000	.02371	.02371
2	.04742	6.417	.97629	.97629

Appendix 7

Variable(s) Entered on Step Number
2.. MED

Multiple R	.53551
R Square	.28677
Adjusted R Square	.24355
Standard Error	.11536

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	2	.17656	.08828
Residual	33	.43913	.01331

F = 6.63432 Signif F = .0038

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
MED	-.088642	.039109	-.334167	.994286	1.006	-2.267
SX	.103683	.038802	.393958	.994286	1.006	2.672
(Constant)	2.622125	.068859				38.080

------ in ------

Variable	Sig T
MED	.0301
SX	.0116
(Constant)	.0000

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
ADLOG	.205939	.239506	.964680	1.037	.959215	1.395	.1725
AMLOG	-.026968	-.028967	.822877	1.215	.822877	-.164	.8708
AUD	.022433	.025908	.951280	1.051	.951280	.147	.8844
EATLOG	.348992	.362289	.768608	1.301	.768608	2.199	.0352
BPVSLOG	.120592	.136848	.918476	1.089	.918476	.781	.4403
FB	-.198269	-.175074	.556111	1.798	.556111	-1.006	.3220
PED	.327900	.317368	.668144	1.497	.668144	1.893	.0674
PL	-.024558	-.028770	.978859	1.022	.974658	-.163	.8717
WIPPLOG	-.070357	-.072321	.753597	1.327	.753597	-.410	.6844
PA3LOG	.213750	.241479	.910278	1.099	.906777	1.408	.1689
PA4LOG	.191657	.224570	.979226	1.021	.974988	1.304	.2017
PA1LOG	.095425	.110149	.950299	1.052	.944908	.627	.5352

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	MED	SX
1	2.62396	1.000	.01070	.04619	.01219
2	.33200	2.811	.02196	.87193	.05761
3	.04403	7.720	.96735	.08188	.93021

Variable(s) Entered on Step Number
3.. EATLOG

Multiple R	.61676
R Square	.38039
Adjusted R Square	.32230
Standard Error	.10919

Appendix 7

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	3	.23420	.07807
Residual	32	.38149	.01192

F = 6.54838 Signif F = .0014

------------------------ Variables in the Equation ------------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
EATLOG	.248371	.112958	.348992	.768608	1.301	2.199
MED	-.122770	.040140	-.462822	.845621	1.183	-3.059
SX	.072626	.039350	.275952	.866173	1.155	1.846
(Constant)	1.702120	.423461				4.020

------ in -------

Variable	Sig T
EATLOG	.0352
MED	.0045
SX	.0742
(Constant)	.0003

---------------------- Variables not in the Equation ----------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
ADLOG	.070310	.076503	.733573	1.363	.584474	.427	.6722
AMLOG	-.128279	-.142248	.761912	1.312	.711663	-.800	.4297
AUD	.010420	.012901	.949881	1.053	.767478	.072	.9432
BPVSLOG	-.043536	-.046431	.704764	1.419	.589768	-.259	.7975
FB	-.198819	-.188355	.556110	1.798	.529482	-1.068	.2938
PED	.327512	.340096	.668144	1.497	.607129	2.014	.0528
PL	.069994	.084272	.898179	1.113	.705258	.471	.6410
WIPPLOG	-.273502	-.272068	.613130	1.631	.613130	-1.574	.1256
PA3LOG	.141730	.166205	.852088	1.174	.719475	.938	.3553
PA4LOG	.092891	.109041	.853782	1.171	.670146	.611	.5458
PA1LOG	.080682	.099805	.948150	1.055	.766870	.558	.5805

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	EATLOG	MED	SX
1	3.59014	1.000	.00014	.00012	.01973	.00574
2	.35202	3.194	.00027	.00019	.78949	.02710
3	.05697	7.938	.00683	.00449	.06105	.87711
4	.00087	64.182	.99276	.99520	.12973	.09005

End Block Number 1 PIN = .050 Limits reached.

Residuals Statistics:

	Min	Max	Mean	Std Dev	N
*PRED	2.5554	2.8917	2.7337	.0856	41
*RESID	-.2050	.3272	.0009	.1027	41
*ZPRED	-2.1547	1.9559	.0247	1.0462	41
*ZRESID	-1.8776	2.9966	.0079	.9402	41

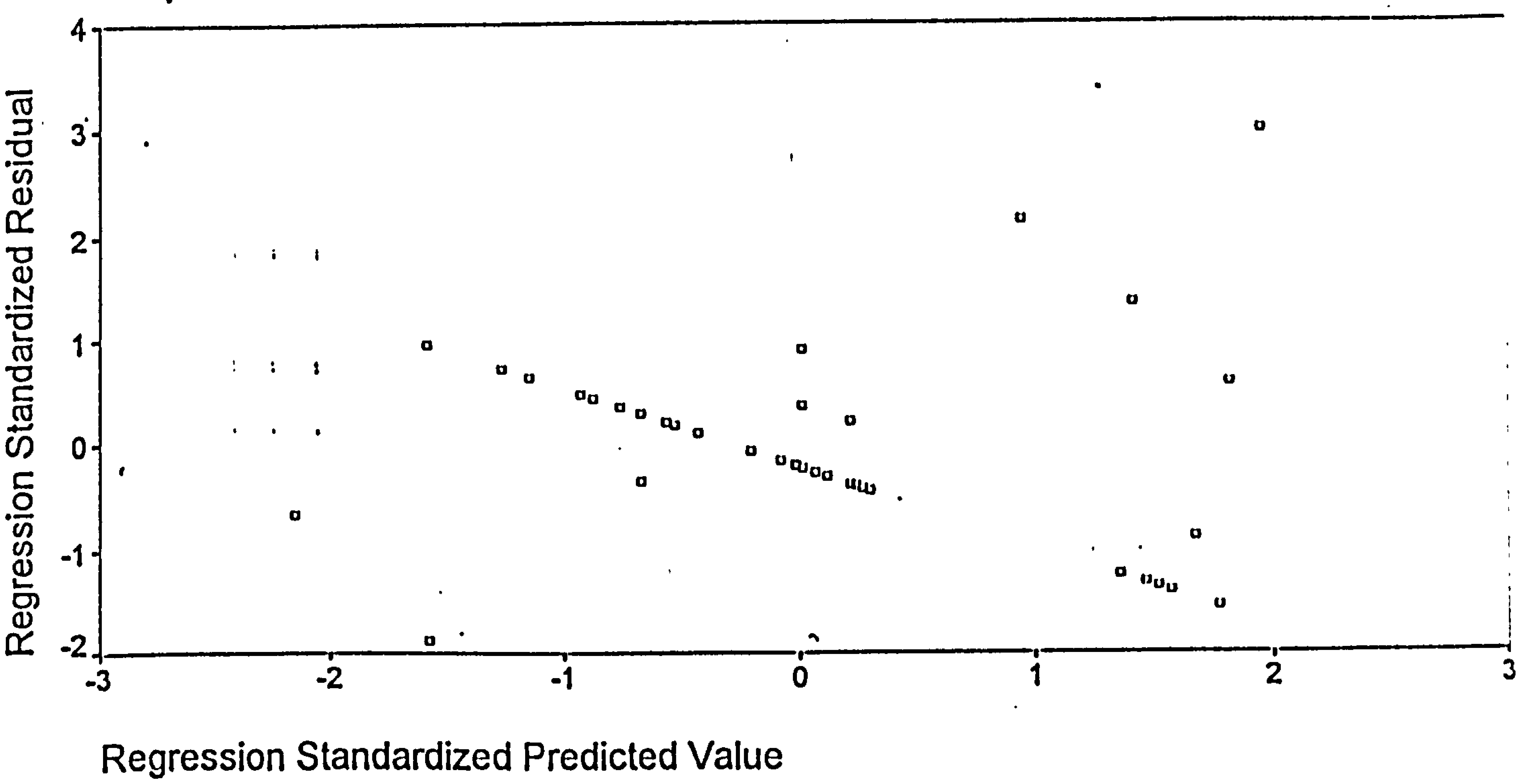
Total Cases = 41

Hi-Res Chart # 14:Normal p-p plot of *zresid
Hi-Res Chart # 13:Scatterplot of *zresid with *zpred

Appendix 7

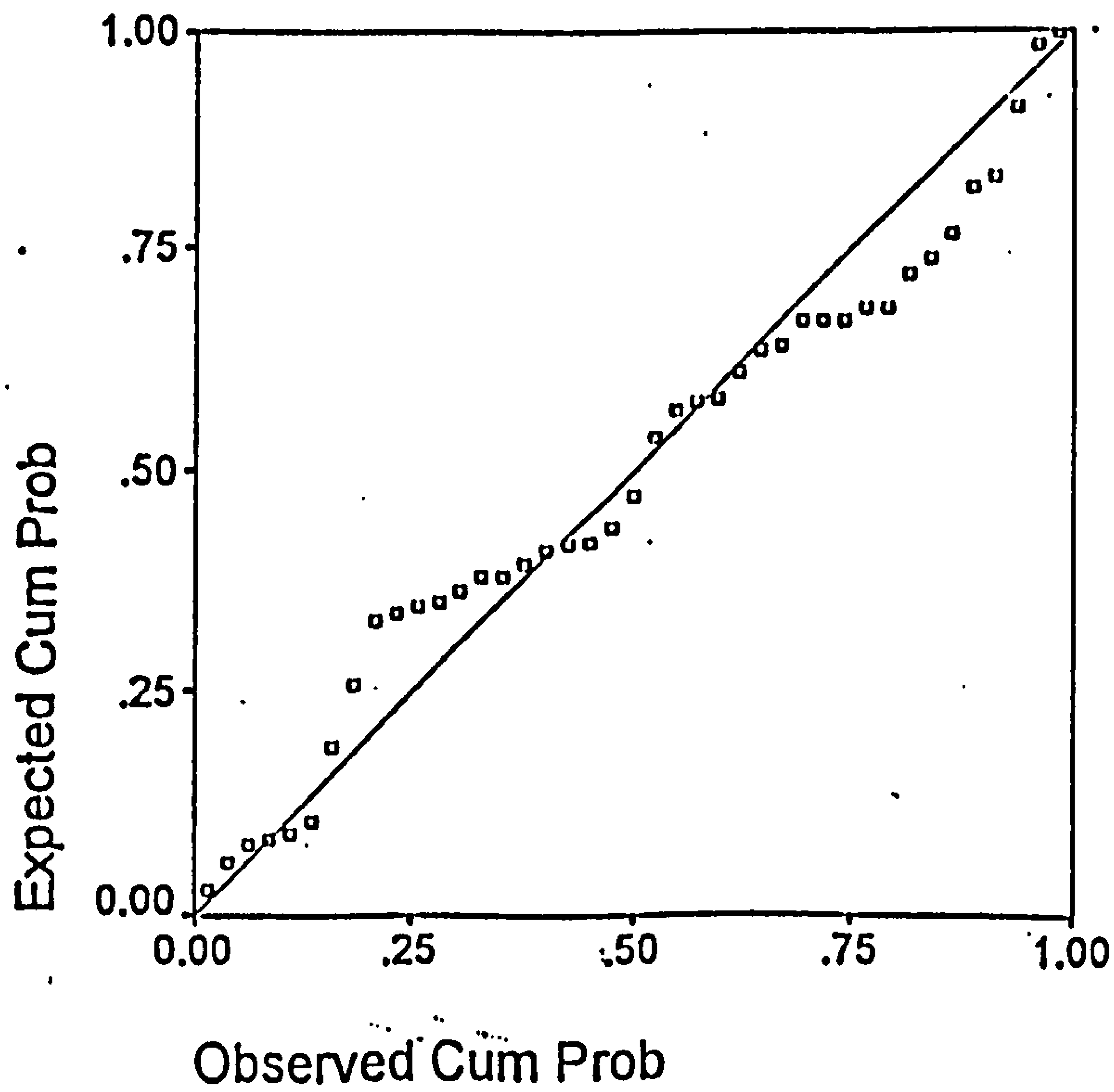
Scatterplot

Dependent Variable: PA2LOG



Normal P-P Plot of Regression Standardized

Dependent Variable: PA2LOG



Appendix 7
Stepwise Multiple Regression

Dependent variable: subtest pa3 (at four years old)
Independent variables: test scores at four years old.

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. PA3LOG

Block Number 1. Method: Stepwise Criteria PIN .0500 POUT .1000
ADLOG AMLOG AUD BPVSLOG EATLOG FB MED PA1LOG
PA4LOG PED PL SX WIPPLOG PA2LOG

Variable(s) Entered on Step Number
1.. PL

Multiple R	.45008
R Square	.20257
Adjusted R Square	.17912
Standard Error	.21274

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	.39091	.39091
Residual	34	1.53881	.04526

F = 8.63718 Signif F = .0059

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
PL	.211366	.071920	.450082	1.000000	1.000	2.939
(Constant)	2.333315	.054930				42.478

----- in -----

Variable	Sig T
PL	.0059
(Constant)	.0000

Equation Number 1 Dependent Variable.. PA3LOG

---------------- Variables not in the Equation ----------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
ADLOG	.346386	.380700	.963245	1.038	.963245	2.365	.0241
AMLOG	.394869	.431392	.951763	1.051	.951763	2.747	.0097
AUD	.139428	.156025	.998571	1.001	.998571	.907	.3708
BPVSLOG	.526545	.574522	.949366	1.053	.949366	4.032	.0003
EATLOG	.506146	.542631	.916535	1.091	.916535	3.711	.0008
FB	-.163305	-.182003	.990476	1.010	.990476	-1.063	.2954
MED	.363994	.403433	.979592	1.021	.979592	2.533	.0163
PA1LOG	.058366	.065361	.999998	1.000	.999998	.376	.7091
PA4LOG	.346468	.387986	.999990	1.000	.999990	2.418	.0213
PED	.079526	.086061	.933878	1.071	.933878	.496	.6230
SX	.026331	.029465	.998571	1.001	.998571	.169	.8666
WIPPLOG	.279488	.310719	.985594	1.015	.985594	1.878	.0693
PA2LOG	.096742	.108254	.998511	1.001	.998511	.626	.5359

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	PL
1	1.76376	1.000	.11812	.11812
2	.23624	2.732	.88188	.88188

Appendix 7

Variable(s) Entered on Step Number
2.. BPVSLOG

Multiple R	.68248
R Square	.46578
Adjusted R Square	.43341
Standard Error	.17675

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	2	.89883	.44942
Residual	33	1.03089	.03124

F = 14.38643 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
BPVSLOG	.413062	.102439	.526545	.949366	1.053	4.032
PL	.267008	.061324	.568566	.949366	1.053	4.354
(Constant)	.799303	.383160				2.086

----- in -----

Variable	Sig T
BPVSLOG	.0003
PL	.0001
(Constant)	.0448

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
ADLOG	.092561	.104885	.685947	1.458	.676063	.597	.5550
AMLOG	.177839	.206138	.717763	1.393	.715956	1.192	.2421
AUD	.094243	.128332	.990576	1.010	.941764	.732	.4695
EATLOG	.314932	.355031	.678915	1.473	.678915	2.148	.0394
FB	-.035268	-.046464	.927205	1.079	.888720	-.263	.7941
MED	.265029	.350539	.934550	1.070	.905714	2.117	.0421
PA1LOG	-.036964	-.049715	.966366	1.035	.917436	-.282	.7801
PA4LOG	.137299	.166230	.783064	1.277	.743421	.954	.3474
PED	-.012619	-.016433	.905974	1.104	.904107	-.093	.9265
SX	-.051994	-.070279	.976022	1.025	.927928	-.399	.6929
WIPPLOG	-.003778	-.004299	.691814	1.445	.666384	-.024	.9807
PA2LOG	.047673	.064873	.989225	1.011	.940537	.368	.7155

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	BPVSLOG	PL
1	2.67877	1.000	.00079	.00082	.04266
2	.31819	2.902	.00242	.00311	.88332
3	.00304	29.690	.99679	.99607	.07402

Variable(s) Entered on Step Number
3.. EATLOG

Multiple R	.73015
R Square	.53312
Adjusted R Square	.48935
Standard Error	.16779

Appendix 7

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	3	1.02877	.34292
Residual	32	.90095	.02815

F = 12.18008 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
BPVSLOG	.289461	.112994	.368986	.703234	1.422	2.562
EATLOG	.396796	.184702	.314932	.678915	1.473	2.148
PL	.293086	.059470	.624097	.909810	1.099	4.928
(Constant)	-.345382	.645154				-.535

----- in -----

Variable	Sig T
BPVSLOG	.0153
EATLOG	.0394
PL	.0000
(Constant)	.5961

------------------ Variables not in the Equation ------------------

Variable	Beta In						
ADLOG	.012470	.014602	.640188	1.562	.593363	.081	.9357
AMLOG	.129202	.157835	.696739	1.435	.601894	.890	.3804
AUD	.115876	.168243	.984217	1.016	.674556	.950	.3493
FB	.016241	.022475	.894089	1.118	.654666	.125	.9012
MED	.211286	.289513	.876594	1.141	.636812	1.684	.1022
PA1LOG	-.048632	-.069900	.964508	1.037	.677609	-.390	.6991
PA4LOG	.081443	.103305	.751179	1.331	.623501	.578	.5673
PED	-.046790	-.064687	.892322	1.121	.668684	-.361	.7206
SX	-.145517	-.200397	.885439	1.129	.615906	-1.139	.2635
WIPPLOG	-.137146	-.155232	.598144	1.672	.586991	-.875	.3884
PA2LOG	-.031429	-.043742	.904385	1.106	.620688	-.244	.8090

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	BPVSLOG	EATLOG	PL
1	3.64386	1.000	.00014	.00034	.00011	.02049
2	.35193	3.218	.00030	.00097	.00028	.86444
3	.00333	33.085	.16029	.88135	.03407	.04621
4	.00088	64.467	.83928	.11734	.96555	.06886

End Block Number 1 PIN = .050 Limits reached.

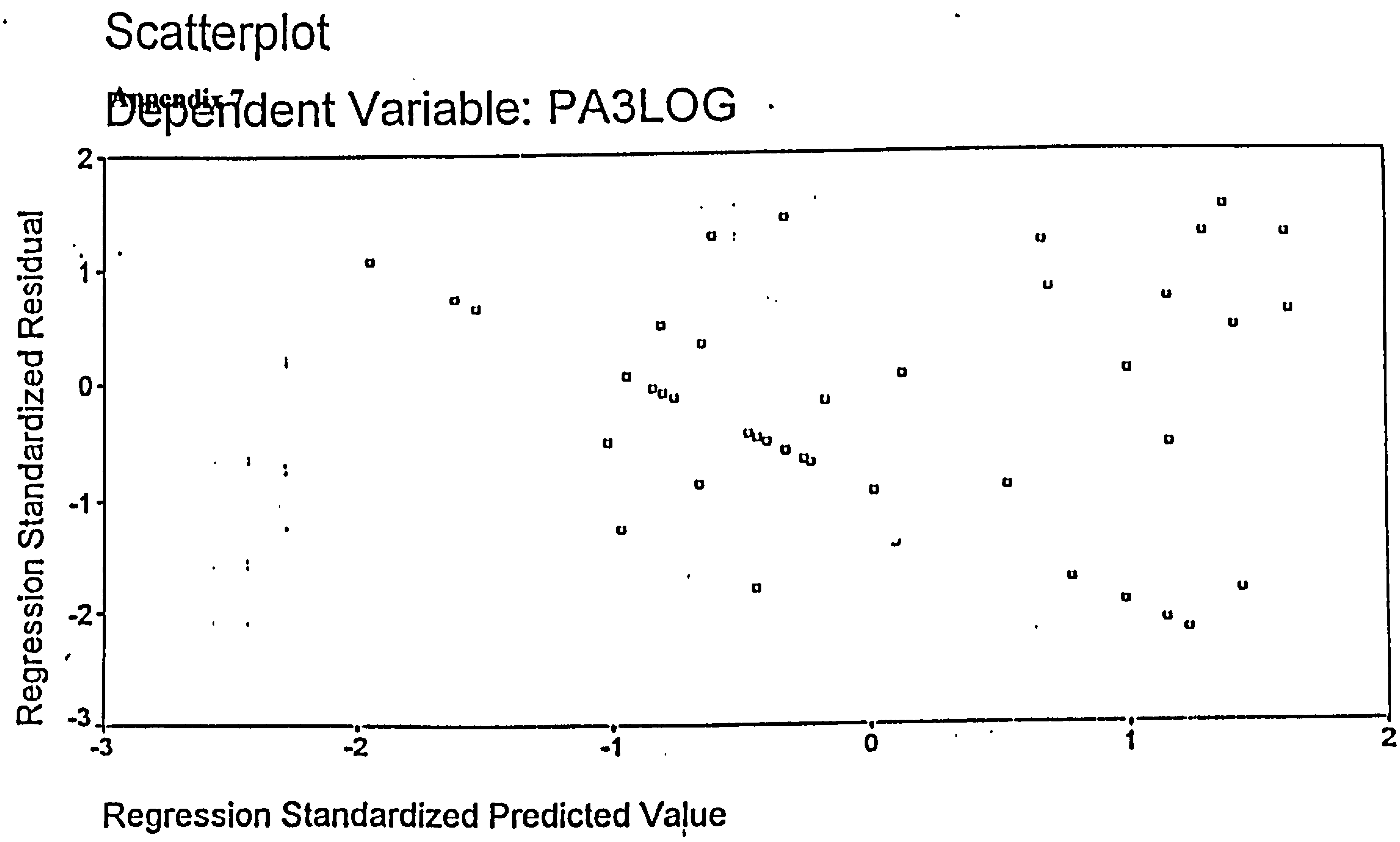
Residuals Statistics:

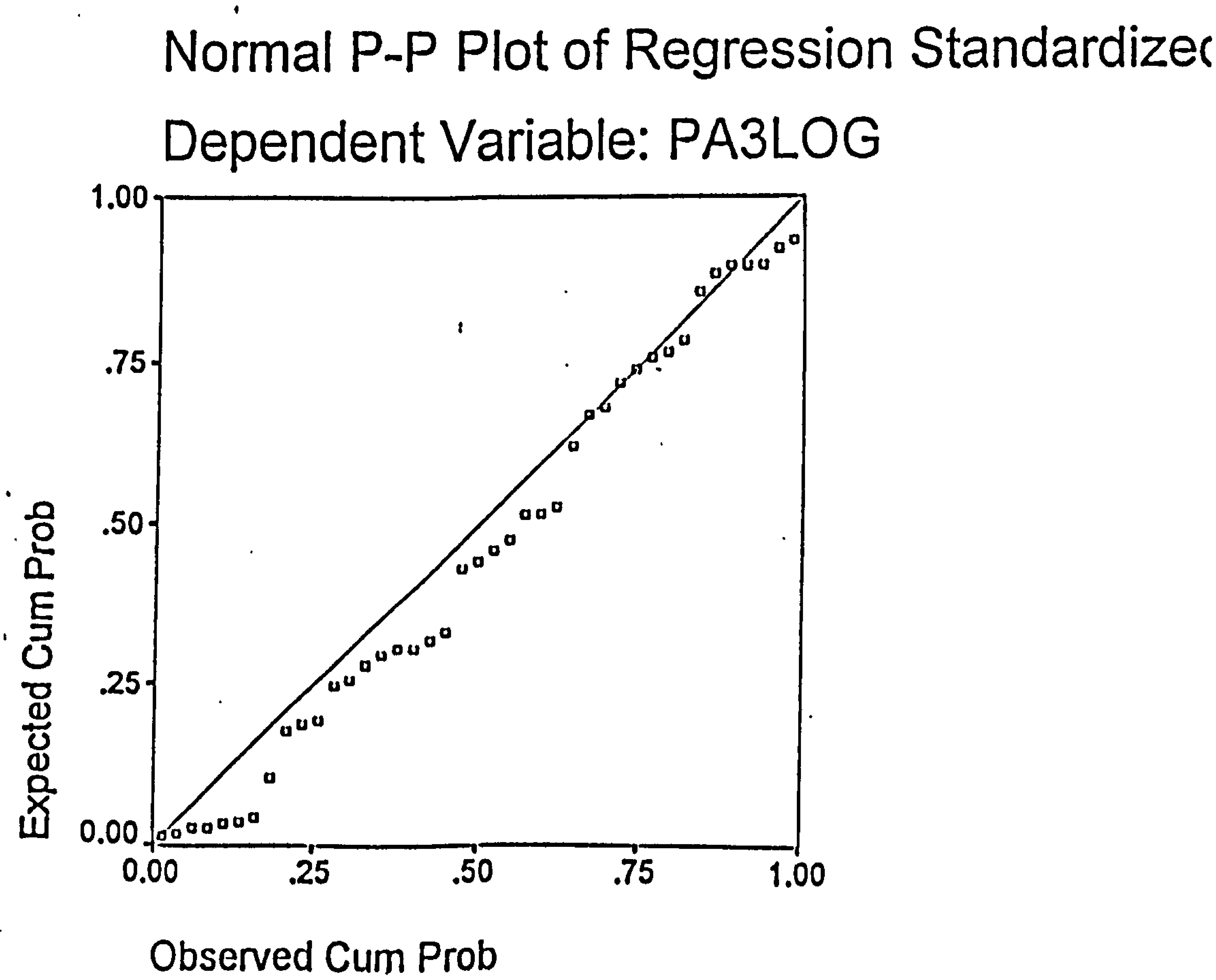
	Min	Max	Mean	Std Dev	N
*PRED	2.1222	2.7346	2.4686	.1701	41
*RESID	-.3645	.2532	-.0339	.1786	41
*ZPRED	-1.9505	1.6213	.0701	.9922	41
*ZRESID	-2.1725	1.5089	-.2022	1.0644	41

Total Cases = 41

Hi-Res Chart # 6:Normal p-p plot of *zresid
Hi-Res Chart # 5:Scatterplot of *zresid with *zpred

Appendix 7


Scatterplot
Dependent Variable: PA3LOG
Regression Standardized Residual
Regression Standardized Predicted Value
2
1
0
-1
-2
-3
-3
-2
-1
0
1
2


Normal P-P Plot of Regression Standardized
Dependent Variable: PA3LOG
Expected Cum Prob
Observed Cum Prob
1.00
.75
.50
.25
0.00
0.00
.25
.50
.75
1.00

Appendix 7

Stepwise Multiple Regression **Dependent variable: subtest pa4 (at four years old)**
Independent variables: test scores at four years old.

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. PA4LOG

Block Number 1. Method: Stepwise Criteria PIN .0500 POUT .1000
ADLOG AMLOG AUD BPVSLOG EATLOG FB MED PA1LOG
PED PL SX WIPPLOG PA2LOG PA3LOG

Variable(s) Entered on Step Number
1.. AMLOG

Multiple R	.47423
R Square	.22490
Adjusted R Square	.20210
Standard Error	.17813

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	.31302	.31302
Residual	34	1.07883	.03173

F = 9.86510 Signif F = .0035

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
AMLOG	.289832	.092277	.474232	1.000000	1.000	3.141
(Constant)	2.060604	.238395				8.644

----- in -----

Variable	Sig T
AMLOG	.0035
(Constant)	.0000

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
ADLOG	.289314	.290325	.780531	1.281	.780531	1.743	.0907
AUD	.013216	.014909	.986531	1.014	.986531	.086	.9323
BPVSLOG	.282852	.274277	.728819	1.372	.728819	1.638	.1108
EATLOG	.211830	.218498	.824668	1.213	.824668	1.286	.2073
FB	-.006129	-.006274	.812157	1.231	.812157	-.036	.9715
MED	-.013587	-.014660	.902262	1.108	.902262	-.084	.9334
PA1LOG	.138788	.151504	.923632	1.083	.923632	.880	.3850
PED	-.186335	-.195836	.856160	1.168	.856160	-1.147	.2595
PL	.112722	.124909	.951763	1.051	.951763	.723	.4746
SX	-.090724	-.099579	.933789	1.071	.933789	-.575	.5693
WIPPLOG	.140267	.120674	.573690	1.743	.573690	.698	.4899
PA2LOG	.169029	.191929	.999360	1.001	.999360	1.123	.2694
PA3LOG	.234515	.255952	.923287	1.083	.923287	1.521	.1378

Appendix 7

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	AMLOG
1	1.99222	1.000	.00389	.00389
2	.00778	15.997	.99611	.99611

Residuals Statistics:

	Min	Max	Mean	Std Dev	N
*PRED	2.5799	3.0366	2.8120	.0947	41
*RESID	-.7246	.2470	-.0301	.2039	41
*ZPRED	-2.3647	2.4639	.0893	1.0016	41
*ZRESID	-4.0676	1.3867	-.1689	1.1446	41

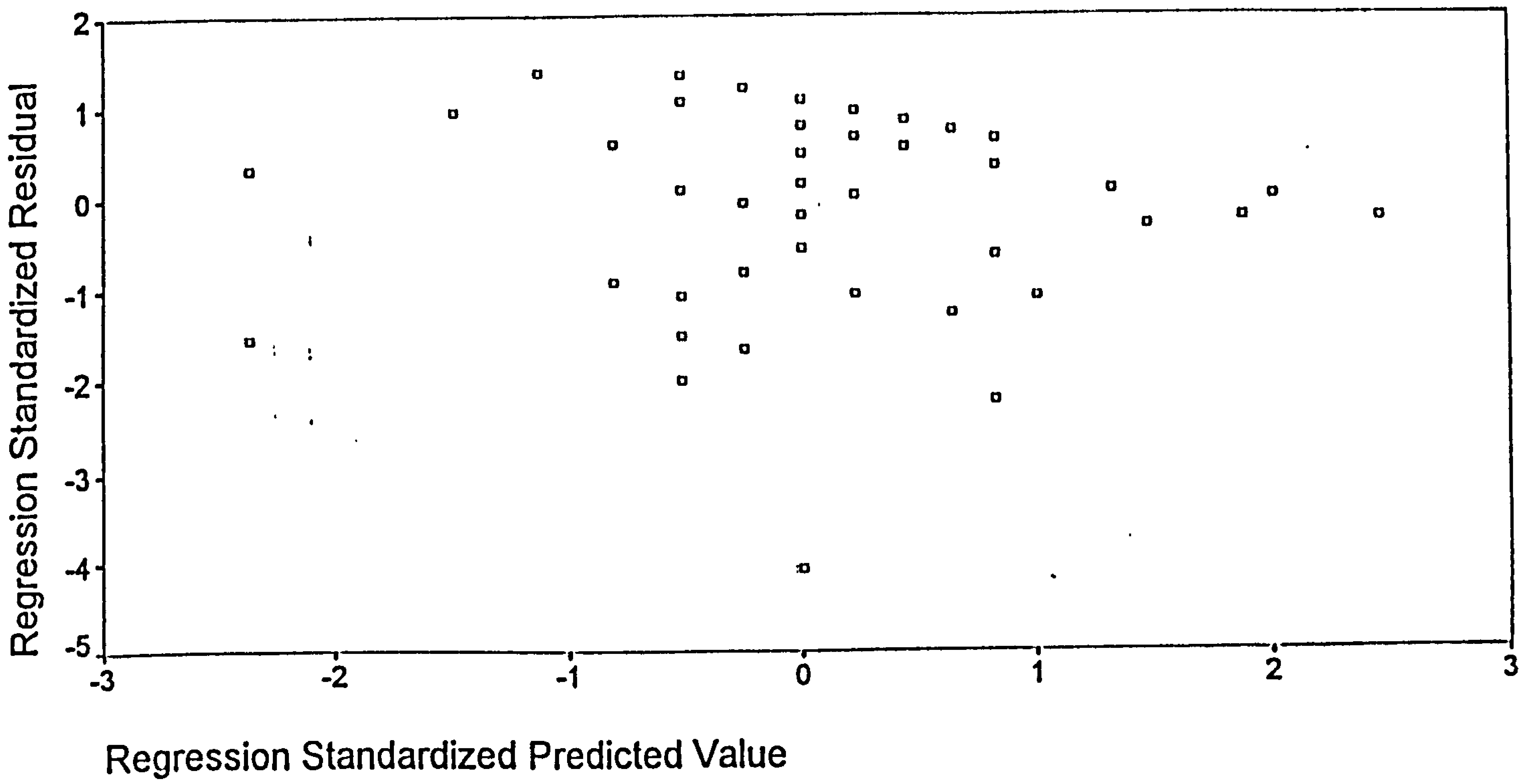
Total Cases = 41

Hi-Res Chart # 8:Normal p-p plot of *zresid
Hi-Res Chart # 7:Scatterplot of *zresid with *zpred

Appendix 7

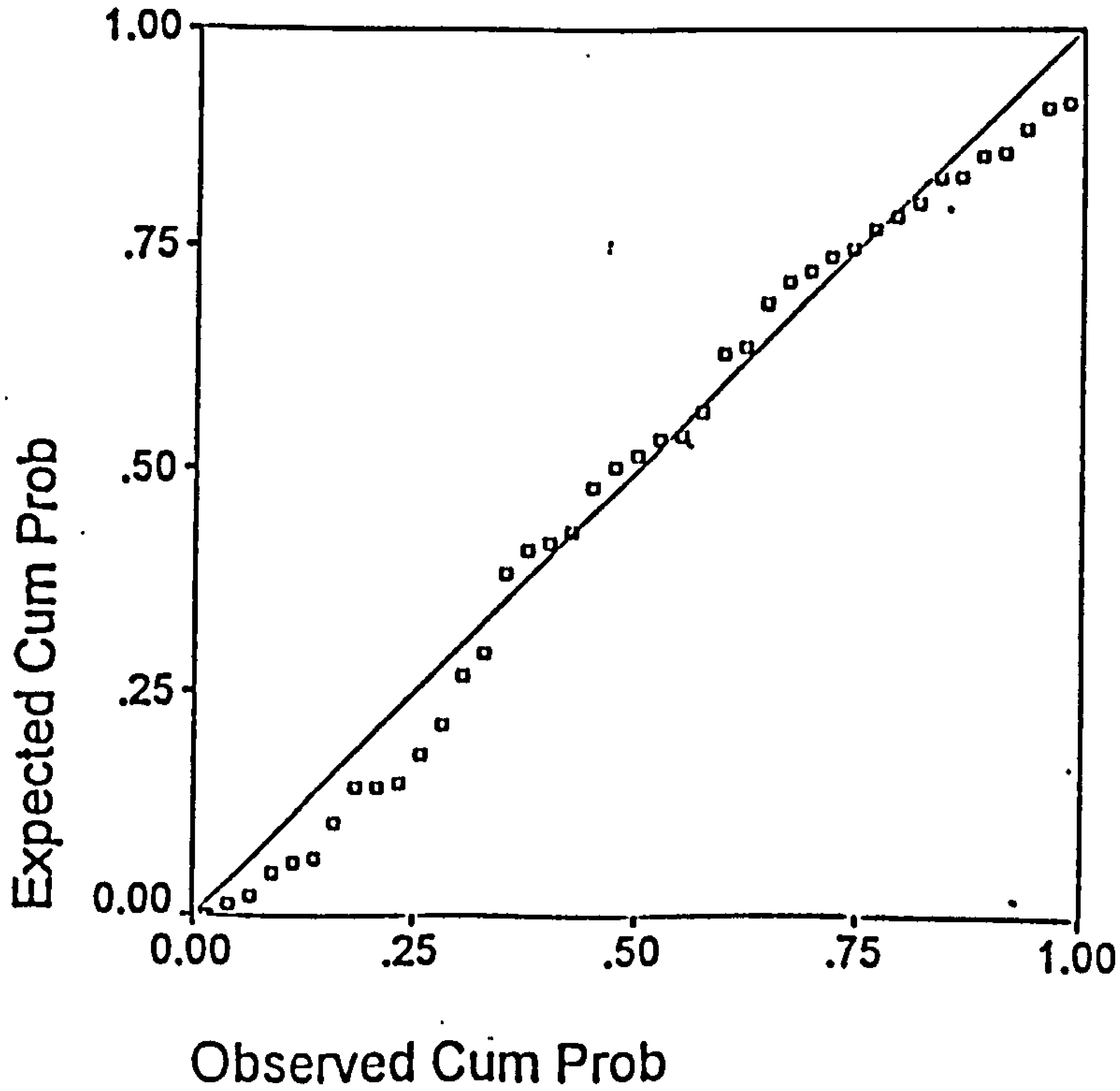
Scatterplot

Dependent Variable: PA4LOG



Normal P-P Plot of Regression Standardized

Dependent Variable: PA4LOG



APPENDIX 8

EXPERIMENT 2

Raw Data

Appendix 8

Subject	sx	2pa1	2pa1a	2pa2	2pa3	2pa4	2PA total	2 EAT	2blocks	2AM	2PM	2AD	FB	PL	AUD	MED	PED	ST	SCH
1	2	30	20	22	19	15	86	66	18	16	22	17	2	1	1	0	0	0	1
2	2	30	20	25	20	18	93	53	21	25	38	20	2	1	0	0	0	1	1
3	1	29	19	29	17	20	95	51	27	27	31	18	1	0	0	1	1	0	1
4	1	30	20	30	20	20	100	68	21	26	31	19	1	1	1	1	1	0	1
5	2	28	19	15	14	20	77	59	25	17	32	18	1	1	0	1	1	0	1
6	2	30	20	14	11	19	74	52	15	12	22	18	3	1	0	0	0	0	0
7	2	30	20	24	15	13	82	66	19	14	23	19	2	0	0	1	1	0	1
8	1	28	20	15	10	13	66	42	6	8	9	18	3	1	0	0	0	0	1
9	2	16	13	21	13	11	61	59	10	14	2	13	2	1	1	0	0	0	1
10	1	30	20	29	15	18	93	62	22	29	25	18	3	1	1	1	1	0	1
11	2	28	19	26	17	20	91	61	11	19	31	14	1	1	1	0	1	1	1
12	2	30	20	25	20	20	95	62	20	15	28	20	1	1	0	1	1	0	1
13	2	29	19	15	16	12	72	65	20	23	33	20	1	0	0	1	1	0	1
15	2	30	20	25	17	10	82	43	21	20	15	18	2	1	1	0	1	0	1
16	1	18	14	16	10	20	64	42	14	19	16	18	2	1	0	0	0	0	0
18	1	30	20	20	17	19	86	60	12	14	23	16	2	1	0	0	0	0	1
19	1	30	20	23	18	18	87	40	22	23	26	18	2	0	1	1	0	0	1
20	2	30	20	27	16	18	91	63	25	14	27	17	3	1	0	0	0	0	1
21	2	30	20	30	20	12	92	61	30	22	27	18	2	1	1	1	0	10	1
22	1	30	20	15	18	14	77	61	5	15	22	20	2	0	1	1	1	0	0
23	1	30	20	23	20	20	93	59	25	21	29	17	1	1	0	1	1	0	0
24	2	30	20	30	20	19	99	68	12	19	29	17	2	0	0	0	1	0	1
25	1	30	20	12	13	14	69	46	22	17	10	15	3	0	0	0	0	0	1
26	1	30	20	21	13	17	81	44	19	12	13	13	3	0	1	0	0	0	1
27	2	30	20	29	19	20	98	68	23	28	33	20	2	0		0	1	0	1
28	1	30	20	23	16	20	89	60	21	15	17	17	1	1	0	1	1	0	0
30	2	30	20	28	18	18	94	62	19	17	21	19	1	1	0	1	1	0	0
31	2	30	20	23	19	19	91	65	19	23	34	18	1	0	1	1	1	0	0
33	2	30	20	14	13	20	77	67	20	25	17	19	2	0	0	0	0	0	0
34	1	27	18	15	11	15	68	59	10	12	21	14	2	1	1	1	0	0	0
35	1	30	20	15	16	20	81	62	10	24	29	19	1	0	1	1	1	0	0
36	1	30	20	25	20	12	87	61	21	22	29	20	1	1		1	1	0	0
37	2	30	20	24	19	20	93	61	27	22	17	17	1	0	0	1	1	0	0
38	2	30	20	24	18	19	91	60	21	25	31	20	1	0	1	1	1	0	0
39	2	30	20	27	19	17	93	53	32	29	27	18	1	0		1	1	0	0
40	2	30	20	23	19	16	88	67	16	15	24	20	2	1		0	0	0	0
41	1	30	20	15	9	20	74	49	27	27	33	20	2	0	1	0	1	0	0
42	1	30	20	15	20	19	84	60	22	24	28	18	2	1	1	1	0	0	0
43	1	30	20	25	15	20	90	61	19	24	26	19	1	1		1	1	0	0
44	2	30	20	29	19	20	98	64	17	25	27	19	1	1	0	1	1	0	0
45	2	30	20	26	19	19	94	62	19	23	27	18	1	0	0	1	1	0	0

APPENDIX 9

EXPERIMENT 2

Univariate Analyses

Appendix 9

Summary Statistics

Speech Perception (AD)

Valid cases:	41.0	Missing cases:	.0	Percent missing:	.0		
Mean	17.9024	Std Err	.2959	Min	13.0000	Skewness	-1.1510
Median	18.0000	Variance	3.5902	Max	20.0000	S E Skew	.3695
5% Trim	18.0569	Std Dev	1.8948	Range	7.0000	Kurtosis	1.0239
95% CI for Mean (17.3044, 18.5005)				IQR	2.0000	S E Kurt	.7245

```
Frequency   Stem & Leaf
  4.00 Extremes   (13.0), (14.0)
  1.00     15 * 0
   .00     15 .
  1.00     16 * 0
   .00     16 .
  6.00     17 * 000000
   .00     17 .
 13.00     18 * 0000000000000
   .00     18 .
  7.00     19 * 0000000
   .00     19 .
  9.00     20 * 000000000
Stem width:    1.00
Each leaf:     1 case(s)
```

Speech Perception (ADLG)

Valid cases:	41.0	Missing cases:	.0	Percent missing:	.0		
Mean	2.8789	Std Err	.0178	Min	2.5649	Skewness	-1.4178
Median	2.8904	Variance	.0130	Max	2.9957	S E Skew	.3695
5% Trim	2.8898	Std Dev	.1140	Range	.4308	Kurtosis	1.7259
95% CI for Mean (2.8429, 2.9149)				IQR	.1112	S E Kurt	.7245

Auditory Memory (AM)

Valid cases:	41.0	Missing cases:	.0	Percent missing:	.0		
Mean	20.0244	Std Err	.8493	Min	8.0000	Skewness	-.1905
Median	21.0000	Variance	29.5744	Max	29.0000	S E Skew	.3695
5% Trim	20.0813	Std Dev	5.4382	Range	21.0000	Kurtosis	-.9713
95% CI for Mean (18.3079, 21.7409)				IQR	9.5000	S E Kurt	.7245

```
Frequency   Stem & Leaf
  1.00     0 . 8
  7.00     1 * 2224444
 11.00     1 . 55556777999
 12.00     2 * 012223333444
 10.00     2 . 5555677899
Stem width:   10.00
Each leaf:     1 case(s)
```

Auditory Memory (AMLG)

Valid cases:	41.0	Missing cases:	.0	Percent missing:	.0		
Mean	2.9563	Std Err	.0467	Min	2.0794	Skewness	-.7415
Median	3.0445	Variance	.0895	Max	3.3673	S E Skew	.3695
5% Trim	2.9707	Std Dev	.2992	Range	1.2879	Kurtosis	.1700
95% CI for Mean (2.8619, 3.0508)				IQR	.4904	S E Kurt	.7245

Appendix 9

Speech Production (EAT)

Valid cases:	41.0	Missing cases:	.0	Percent missing:	.0		
Mean	58.3902	Std Err	1.2381	Min	40.0000	Skewness	-1.0196
Median	61.0000	Variance	62.8439	Max	68.0000	S E Skew	.3695
5% Trim	58.8211	Std Dev	7.9274	Range	28.0000	Kurtosis	.0348
95% CI for Mean	(55.8880, 60.8924)			IQR	10.5000	S E Kurt	.7245

```
Frequency   Stem & Leaf
  5.00      4 * 02234
  2.00      4 . 69
  4.00      5 * 1233
  4.00      5 . 9999
 17.00      6 * 00001111112222234
  9.00      6 . 556677888
Stem width:  10.00
Each leaf:   1 case(s)
```

Speech Production (EATLG)

Valid cases:	41.0	Missing cases:	.0	Percent missing:	.0		
Mean	4.0571	Std Err	.0231	Min	3.6889	Skewness	-1.2213
Median	4.1109	Variance	.0219	Max	4.2195	S E Skew	.3695
5% Trim	4.0671	Std Dev	.1479	Range	.5306	Kurtosis	.4449
95% CI for Mean	(4.0104, 4.1038)			IQR	.1807	S E Kurt	.7245

Nonverbal Cognitive Skills (BL)

Valid cases:	41.0	Missing cases:	.0	Percent missing:	.0		
Mean	19.1463	Std Err	.9542	Min	5.0000	Skewness	-.3770
Median	20.0000	Variance	37.3280	Max	32.0000	S E Skew	.3695
5% Trim	19.2453	Std Dev	6.1097	Range	27.0000	Kurtosis	.0617
95% CI for Mean	(17.2179, 21.0748)			IQR	6.5000	S E Kurt	.7245

```
Frequency   Stem & Leaf
  2.00 Extremes   (5), (6)
  7.00      1 * 0001224
 10.00      1 . 5678999999
 14.00      2 * 00011111122223
  6.00      2 . 555777
  1.00      3 * 0
  1.00 Extremes   (32)
Stem width:  10.00
Each leaf:   1 case(s)
```

Nonverbal Cognitive Skills (BCKLG)

Valid cases:	41.0	Missing cases:	.0	Percent missing:	.0		
Mean	2.8866	Std Err	.0624	Min	1.6094	Skewness	-1.4556
Median	2.9957	Variance	.1598	Max	3.4657	S E Skew	.3695
5% Trim	2.9215	Std Dev	.3998	Range	1.8563	Kurtosis	2.3115
95% CI for Mean	(2.7604, 3.0128)			IQR	.3507	S E Kurt	.7245

Appendix 9

Phonological Memory (PM)

Valid cases: 41.0 Missing cases: .0 Percent missing: .0

Mean	24.5122	Std Err	1.1905	Min	2.0000	Skewness	-.9156
Median	27.0000	Variance	58.1061	Max	38.0000	S E Skew	.3695
5% Trim	24.9282	Std Dev	7.6227	Range	36.0000	Kurtosis	.7980
95% CI for Mean (22.1062, 26.9182)				IQR	9.0000	S E Kurt	.7245

```
Frequency    Stem &  Leaf
  2.00 Extremes    (2), (9)
  2.00        1 *  03
  5.00        1 .  56777
  8.00        2 *  11222334
 14.00        2 .  56677777889999
  9.00        3 *  111123334
  1.00        3 .  8
Stem width:   10.00
Each leaf:     1 case(s)
```

Phonological Memory (PMLG)

Valid cases: 41.0 Missing cases: .0 Percent missing: .0

Mean	3.1159	Std Err	.0788	Min	.6931	Skewness	-3.1132
Median	3.2958	Variance	.2545	Max	3.6376	S E Skew	.3695
5% Trim	3.1818	Std Dev	.5045	Range	2.9444	Kurtosis	12.9059
95% CI for Mean (2.9567, 3.2752)				IQR	.3561	S E Kurt	.7245

Phonological Awareness (PA)

Valid cases: 41.0 Missing cases: .0 Percent missing: .0

Mean	85.2683	Std Err	1.6132	Min	61.0000	Skewness	-.7391
Median	88.0000	Variance	106.7012	Max	100.0000	S E Skew	.3695
5% Trim	85.7398	Std Dev	10.3296	Range	39.0000	Kurtosis	-.3909
95% CI for Mean (82.0079, 88.5287)				IQR	16.0000	S E Kurt	.7245

```
Frequency    Stem &  Leaf
  2.00        6 *  14
  3.00        6 .  689
  3.00        7 *  244
  3.00        7 .  777
  5.00        8 *  11224
  6.00        8 .  667789
 13.00        9 *  0111123333344
  5.00        9 .  55889
  1.00       10 *  0
Stem width:   10.00
Each leaf:     1 case(s)
```

Phonological Awareness (PALG)

Valid cases: 41.0 Missing cases: .0 Percent missing: .0

Mean	4.4381	Std Err	.0200	Min	4.1109	Skewness	-.9426
Median	4.4773	Variance	.0165	Max	4.6052	S E Skew	.3695
5% Trim	4.4459	Std Dev	.1283	Range	.4943	Kurtosis	.0278
95% CI for Mean (4.3976, 4.4786)				IQR	.1888	S E Kurt	.7245

Appendix 9

Phonological Awareness: Subtest 1 (pa1)

Valid cases:	41.0	Missing cases:	.0	Percent missing:	.0		
Mean	29.0976	Std Err	.4483	Min	16.0000	Skewness	-4.0027
Median	30.0000	Variance	8.2402	Max	30.0000	S E Skew	.3695
5% Trim	29.7060	Std Dev	2.8706	Range	14.0000	Kurtosis	15.8587
95% CI for Mean	(28.1915, 30.0036)			IQR	.0000	S E Kurt	.7245

```
Frequency   Stem & Leaf
  8.00 Extremes   (16), (18), (27), (28), (29)
 33.00       3 * 000000000000000000000000000000000
Stem width:   10.00
Each leaf:    1 case(s)
```

Subtest 1 (pa1lg)

Valid cases:	41.0	Missing cases:	.0	Percent missing:	.0		
Mean	3.3641	Std Err	.0196	Min	2.7726	Skewness	-4.1748
Median	3.4012	Variance	.0157	Max	3.4012	S E Skew	.3695
5% Trim	3.3910	Std Dev	.1252	Range	.6286	Kurtosis	17.1745
95% CI for Mean	(3.3246, 3.4037)			IQR	.0000	S E Kurt	.7245

Phonological Awareness: Subtest 2 (pa2)

Valid cases:	41.0	Missing cases:	.0	Percent missing:	.0		
Mean	22.2439	Std Err	.8652	Min	12.0000	Skewness	-.3442
Median	23.0000	Variance	30.6890	Max	30.0000	S E Skew	.3695
5% Trim	22.3252	Std Dev	5.5398	Range	18.0000	Kurtosis	-1.2077
95% CI for Mean	(20.4953, 23.9925)			IQR	11.5000	S E Kurt	.7245

```
Frequency   Stem & Leaf
  3.00      1 * 244
  9.00      1 . 555555556
 12.00      2 * 011233333444
 14.00      2 . 55555667789999
  3.00      3 * 000
Stem width:   10.00
Each leaf:    1 case(s)
```

Subtest 2 (pa2lg)

Valid cases:	41.0	Missing cases:	.0	Percent missing:	.0		
Mean	3.0682	Std Err	.0424	Min	2.4849	Skewness	-.6041
Median	3.1355	Variance	.0737	Max	3.4012	S E Skew	.3695
5% Trim	3.0777	Std Dev	.2715	Range	.9163	Kurtosis	-1.0441
95% CI for Mean	(2.9825, 3.1539)			IQR	.5689	S E Kurt	.7245

Phonological Awareness: Subtest 3 (pa3)

Valid cases:	41.0	Missing cases:	.0	Percent missing:	.0		
Mean	16.4878	Std Err	.5062	Min	9.0000	Skewness	-.7778
Median	17.0000	Variance	10.5061	Max	20.0000	S E Skew	.3695
5% Trim	16.6802	Std Dev	3.2413	Range	11.0000	Kurtosis	-.4234
95% CI for Mean	(15.4647, 17.5109)			IQR	4.5000	S E Kurt	.7245

Appendix 9

Frequency	Stem & Leaf
1.00	Extremes (9.0)
2.00	10 . 00
2.00	11 . 00
.00	12 .
4.00	13 . 0000
1.00	14 . 0
3.00	15 . 000
5.00	16 . 00000
4.00	17 . 0000
3.00	18 . 000
8.00	19 . 00000000
8.00	20 . 00000000

Stem width: 1.00
Each leaf: 1 case(s)

Subtest 3 (pa3lg)

Valid cases: 41.0 Missing cases: .0 Percent missing: .0

Mean	2.7807	Std Err	.0344	Min	2.1972	Skewness	-1.1144
Median	2.8332	Variance	.0486	Max	2.9957	S E Skew	.3695
5% Trim	2.7982	Std Dev	.2205	Range	.7985	Kurtosis	.3975
95% CI for Mean (2.7111, 2.8503)				IQR	.2709	S E Kurt	.7245

Phonological Awareness: Subtest 4 (pa4)

Valid cases: 41.0 Missing cases: .0 Percent missing: .0

Mean	17.4146	Std Err	.4813	Min	10.0000	Skewness	-1.0257
Median	19.0000	Variance	9.4988	Max	20.0000	S E Skew	.3695
5% Trim	17.6531	Std Dev	3.0820	Range	10.0000	Kurtosis	-.3050
95% CI for Mean (16.4418, 18.3874)				IQR	5.0000	S E Kurt	.7245

Frequency	Stem & Leaf
1.00	10 . 0
1.00	11 . 0
3.00	12 . 000
2.00	13 . 00
2.00	14 . 00
2.00	15 . 00
1.00	16 . 0
2.00	17 . 00
5.00	18 . 00000
7.00	19 . 0000000
15.00	20 . 000000000000000

Stem width: 1.00
Each leaf: 1 case(s)

Subtest 4 (pa4lg)

Valid cases: 41.0 Missing cases: .0 Percent missing: .0

Mean	2.8394	Std Err	.0311	Min	2.3026	Skewness	-1.2333
Median	2.9444	Variance	.0397	Max	2.9957	S E Skew	.3695
5% Trim	2.8578	Std Dev	.1992	Range	.6931	Kurtosis	.3327
95% CI for Mean (2.7766, 2.9023)				IQR	.2877	S E Kurt	.7245

Appendix 9
Experiment 2, Subtest pa1: Explanations

#	NON SPECIFIC EXp. unrel	NON SPECIFIC EXP speech rel	MEANING CENTERED EXP	WORD CENTERED EXP	SEGMENT CENTERED EXPLANATION	NOTES
1	just because			cos its not x+	cos it was a ++ not a x+	cos she done it the first time
	cos did			cos she said x+		
2				she said x+	because this is a ++ and she called it a x+.	
				she said x+ and its not	because I can see its a ++ and she said x+	
3				cos its ++	no, not x+, ++ you silly girl	
				its really ++		
4			that's a thing to eat x+ ('date')	because its ++	because x+ isn't right, it should be ++	
				because x+ is stupid, what's a x+ anyway	its a s-s-s-snake	
				because x+ doesn't make sense		
5				it was x+		
				it was xx		
6	-					
7	just did			no you silly, ++		
	no you silly lady silly dumpling					
8		cos we said it		cos her said x+	x+, I call it ++	
				cos we know her said x+		
9				she said xx		
10				cos she said x+ ('tee') - eat my tea	cos she said x+ instead of ++	
				because she said x+	cos it was x+ ('date'), date's a food thing	
11						
12	-					
13	just did			cos they're ++		why does the girl get it right the first time and then wrong?
	a wee bit			x+ said		
				cos she said x+		
14				cos she should have called it ++		
15				cos they're ++		she didn't get it right last time
				cos she didn't say ++		
				cos its ++ and she didn't say ++		
18		just heard		no she said x+	she said x+ instead of ++	
				xal	cos she went xx ('nak') like naked	
19				cos it was ++		
				no it was ++		
20	ooo					
	cos I always know					
21				cos she didn't say ++		she got it right last time
22				cos that is a ++		
				she had to say ++		
				says ++		
				cos I just say ++		
23	cos I did		cos I can recognise the picture	cos they're ++	they're not x+, they're ++	
24	well it might just be that			well, its meant to be ++	because its x+ or something	
				no, ++	because its ++	
				because its maybe, because I think its really meant to be ++		
25	because that's easy		it opens so its ++ (key)	because its ++		
			because its a thing you eat with (spoon)			
26			because its on the picture	because it was a ++ because I know		
				because its on the picture and its ++		
27				cos she said x+	cos she said x+ instead of ++	cos she said x+ instead of ++ but the last time she said ++
				cos you've got to say ++	cos she said x+ instead of ++	
					I had a x+ (date) on holiday	
28		because its not right, maybe she didn't remember what that one was		cos she should have said ++	cos she said ++ not x+, ++	
					cos its not x+ its ++	
					because its not a x+ (wing) thats what birds have, its a ++	
					because it was like x+	
					I thought it was x+ she said	
30			cos we've got a ++ at home	cos its a ++		
				because her didn't say ++		

Appendix 9
Experiment 2, Subtest pa1: Explanations

31				because it sounded like x+		
				because its ++		
				because she said x-		
				because she should have said ++		
33			because look what that one is	cos they're ++	she just said x+ but they're ++	its a ++, she got that one right first time
				no, its a ++	its a ++, it was nearly the same but it wasn't ++	
				its a ++, I know it	he said x+ cos he didn't say ++	
34	and see she, see I did			see she didn't say ++		
	its a funny one			see its ++		
	see she didn't					
35				cos she said x+	no that's not a x+, she said x+ when it was a ++	
				no they're ++	cos she said ++, no, what did she say (asked for replay) she said x- , I can't say it	
				no, she said x+		
				x+ x+!		
36				because she's supposed to say ++	see she said x- and she should have said ++	
				see ++		
37				no she went ++	because she went x+ and its a ++	
				cos its a ++	because they're ++ and she said these were ++	
				x-? she went x-	thats not x+ its a ++	
					x+? because it was ++	
					x+? she went	
					did she say x- or x-	
					cos its a ++ and she said x- but she nearly said x- didn't she	
38				no she said x+	no, she said x+, she should have said ++, part of tea to drink	
				she said x+ (wing) I listened properly and I've got one in my garden		
				see they're ++		
				see she said x-		
39				cos she said x+	x- instead of ++	
				x+ she said x+		
				x+		
40				because she should have said ++	because she said x+, she should have said ++	
				no ++		
				see she said x-		
41				cos she said x+		
				she said x-		
				she called it a x-		
42	see I did			see it was ++		
43	I just did	because she said I don't know		she said x+		
	I don't know			she thought it was x+ probably		
				x+?		
				cos she said x+		
				no she said x+		
				no she said x-		
44				because that's a ++	because that's a ++ and she said x+	
45					because she said x+ instead of ++	
	KEY					
	(++) correct pronunciation	correctly reproduced				
	(+-) correct pronunciation	incorrectly reproduced				
	(x+) mispronunciation	correctly reproduced				
	(x-) mispronunciation	incorrectly reproduced				

Appendix 9
<u>Experiment 2, Subtest pa2: Segmentation skills</u>

Subject	T/15	D/15	S/8	F/7	C(s)vc	C(f)vc	Cvc	cvC
1	7	15	4	3	4	3	7	0
2	10	15	5	5	4	4	8	2
3	14	15	8	6	4	4	8	6
4	15	15	8	7	4	4	8	7
7	10	14	5	5	4	4	8	2
9	10	11	5	5	4	4	8	2
10	15	14	8	7	4	4	8	2
11	11	15	5	6	4	4	8	3
12	10	15	5	5	4	4	8	2
15	10	15	6	4	4	3	7	3
18	6	14	3	3	3	3	6	0
19	8	15	4	4	4	4	8	0
20	12	15	6	6	4	4	8	4
21	15	15	8	7	4	4	8	7
23	9	14	5	4	4	4	8	1
24	15	15	8	7	4	4	8	7
26	9	12	4	5	3	3	6	3
27	14	15	7	7	4	4	8	6
28	8	15	5	3	3	3	6	2
30	13	15	6	7	3	4	7	6
31	8	15	4	4	4	3	7	1
36	10	15	6	4	4	4	8	2
37	11	13	6	5	4	4	8	3
38	9	15	5	4	4	4	8	1
39	12	15	5	7	3	4	7	5
40	8	15	4	4	4	4	8	0
43	11	14	4	7	4	4	8	3
44	14	15	7	7	4	4	8	6
45	12	14	7	5	4	4	8	4
sum	316	420			111	110		
%	70.22	93.33			92.5	91.66		
		sum	163	153			221	90
		%	67.92	72.86			92	42.86
Subject	**strategy**		**Key**					
5	y		T =	contains	item			
6	y (1n)		D =	does not	contain	item		
8	y		S =	all stops				
13	y		F =	all	fricatives			
14	n (1y)		C(s)vc =	stops in	syllable	intial	position	
22	n		C(f)vc =	fricatives	in syllable	initial	position	
33	y		Cvc =	consonant	in syllable	initial	position	
34	y		cvC =	consonant	in syllable	final	position	
35	y		% =	percent	of total	possible	correct	answers
41	y							
42	y							
11								

APPENDIX 10

EXPERIMENT 2

Bivariate Analyses: Differences between Means

Appendix 10

Differences between means: Anovas

Sex

Variable @ADLG
By Variable SX

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0093	.0093	.7113	.4042
Within Groups	39	.5105	.0131		
Total	40	.5198			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.5882	1	39	.448

Variable @AMLG
By Variable SX

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0095	.0095	.1037	.7491
Within Groups	39	3.5711	.0916		
Total	40	3.5806			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
2.3196	1	39	.136

Variable @BCKLG
By Variable SX

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.2637	.2637	1.6781	.2028
Within Groups	39	6.1283	.1571		
Total	40	6.3920			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
7.1066	1	39	.011

Appendix 10

Variable @EATLG
By Variable SX

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.1384	.1384	7.3244	.0100
Within Groups	39	.7370	.0189		
Total	40	.8754			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
10.3074	1	39	.003

Variable @PALG
By Variable SX

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0377	.0377	2.3694	.1318
Within Groups	39	.6204	.0159		
Total	40	.6581			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.5591	1	39	.459

Variable @PMLG
By Variable SX

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0370	.0370	.1422	.7081
Within Groups	39	10.1440	.2601		
Total	40	10.1810			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.0130	1	39	.910

Paternal Education

Variable @ADLG
By Variable PEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0773	.0773	6.8132	.0128
Within Groups	39	.4425	.0113		
Total	40	.5198			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
5.6011	1	39	.023

Appendix 10

Variable @AMLG
By Variable PEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.7748	.7748	10.7699	.0022
Within Groups	39	2.8058	.0719		
Total	40	3.5806			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
3.0852	1	39	.087

Variable @BCKLG
By Variable PEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.2056	.2056	1.2960	.2619
Within Groups	39	6.1865	.1586		
Total	40	6.3920			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.7369	1	39	.396

Variable @EATLG
By Variable PEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.1062	.1062	5.3841	.0256
Within Groups	39	.7692	.0197		
Total	40	.8754			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
11.3233	1	39	.002

Variable @PALG
By Variable PEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.1491	.1491	11.4220	.0017
Within Groups	39	.5090	.0131		
Total	40	.6581			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
6.4991	1	39	.015

Appendix 10

Variable @PMLG
By Variable PEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	1.7493	1.7493	8.0914	.0070
Within Groups	39	8.4316	.2162		
Total	40	10.1810			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
8.4384	1	39	.006

Maternal Education

Variable @ADLG
By Variable MEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0497	.0497	4.1252	.0491
Within Groups	39	.4701	.0121		
Total	40	.5198			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
6.8619	1	39	.012

Variable @AMLG
By Variable MEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.4358	.4358	5.4051	.0254
Within Groups	39	3.1447	.0806		
Total	40	3.5806			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
1.4816	1	39	.231

Variable @BCKLG
By Variable MEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.3365	.3365	2.1675	.1490
Within Groups	39	6.0555	.1553		
Total	40	6.3920			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.6409	1	39	.428

Appendix 10

Variable @EATLG
By Variable MEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0715	.0715	3.4700	.0700
Within Groups	39	.8039	.0206		
Total	40	.8754			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
16.2496	1	39	.000

Variable @PALG
By Variable MEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0779	.0779	5.2352	.0276
Within Groups	39	.5802	.0149		
Total	40	.6581			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
5.0235	1	39	.031

Variable @PMLG
By Variable MEDAGE

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	1.3575	1.3575	6.0001	.0189
Within Groups	39	8.8235	.2262		
Total	40	10.1810			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
11.8346	1	39	.001

Place in Family

Variable @ADLG
By Variable PL

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0069	.0069	.5235	.4737
Within Groups	39	.5129	.0132		
Total	40	.5198			

Appendix 10

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.0496	1	39	.825

Variable @AMLG
By Variable PL

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.3597	.3597	4.3556	.0435
Within Groups	39	3.2209	.0826		
Total	40	3.5806			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.8314	1	39	.367

Variable @BCKLG
By Variable PL

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0657	.0657	.4053	.5281
Within Groups	39	6.3263	.1622		
Total	40	6.3920			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.0020	1	39	.964

Variable @EATLG
By Variable PL

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0015	.0015	.0669	.7972
Within Groups	39	.8739	.0224		
Total	40	.8754			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
2.5848	1	39	.116

Variable @PALG
By Variable PL

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0007	.0007	.0388	.8448
Within Groups	39	.6575	.0169		
Total	40	.6581			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.1955	1	39	.661

Appendix 10

Variable @PMLG
By Variable PL

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.1591	.1591	.6191	.4361
Within Groups	39	10.0219	.2570		
Total	40	10.1810			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.2909	1	39	.593

Family Background

Variable @ADLG
By Variable FB

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0055	.0055	.4850	.4911
Within Groups	33	.3770	.0114		
Total	34	.3825			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
1.2363	1	33	.274

Variable @AMLG
By Variable FB

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.1675	.1675	3.0416	.0905
Within Groups	33	1.8172	.0551		
Total	34	1.9847			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
3.7456	1	33	.062

Variable @BCKLG
By Variable FB

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.3595	.3595	2.5800	.1177
Within Groups	33	4.5982	.1393		
Total	34	4.9577			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
4.0574	1	33	.052

Appendix 10

Variable @EATLG
By Variable FB

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0288	.0288	1.6436	.2088
Within Groups	33	.5775	.0175		
Total	34	.6062			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
13.2413	1	33	.001

Variable @PALG
By Variable FB

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0847	.0847	6.5034	.0156
Within Groups	33	.4299	.0130		
Total	34	.5146			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
4.3233	1	33	.045

Variable @PMLG
By Variable FB

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.6519	.6519	2.8459	.1010
Within Groups	33	7.5593	.2291		
Total	34	8.2112			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
2.9776	1	33	.094

History of Ear Infections

Variable @ADLG
By Variable AUD

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0192	.0192	1.4499	.2369
Within Groups	34	.4502	.0132		
Total	35	.4694			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
8.0587	1	34	.008

Appendix 10

Variable @AMLG
By Variable AUD

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.1090	.1090	1.2312	.2750
Within Groups	34	3.0102	.0885		
Total	35	3.1192			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.0014	1	34	.971

Variable @BCKLG
By Variable AUD

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.1069	.1069	.6242	.4350
Within Groups	34	5.8226	.1713		
Total	35	5.9294			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
2.4907	1	34	.124

Variable @EATLG
By Variable AUD

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0018	.0018	.0749	.7859
Within Groups	34	.8091	.0238		
Total	35	.8108			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.1748	1	34	.679

Variable @PALG
By Variable AUD

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0018	.0018	.1014	.7522
Within Groups	34	.6158	.0181		
Total	35	.6177			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
1.1721	1	34	.287

Appendix 10

Variable @PMLG
By Variable AUD

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0192	.0192	.0661	.7986
Within Groups	34	9.8686	.2903		
Total	35	9.8878			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.6494	1	34	.426

Attendance at school

Variable @ADLG
By Variable SCH

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0356	.0356	2.8636	.0986
Within Groups	39	.4843	.0124		
Total	40	.5198			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
3.0865	1	39	.087

Variable @AMLG
By Variable SCH

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.1174	.1174	1.3216	.2573
Within Groups	39	3.4632	.0888		
Total	40	3.5806			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.7382	1	39	.395

Variable @BCKLG
By Variable SCH

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0082	.0082	.0504	.8236
Within Groups	39	6.3838	.1637		
Total	40	6.3920			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.0014	1	39	.970

Appendix 10

Variable @PALG
By Variable SCH

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0002	.0002	.0090	.9247
Within Groups	39	.6580	.0169		
Total	40	.6581			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
.2426	1	39	.625

Variable @PMLG
By Variable SCH

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.2023	.2023	.7908	.3793
Within Groups	39	9.9786	.2559		
Total	40	10.1810			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
5.4380	1	39	.025

Variable @EATLG
By Variable SCH

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0168	.0168	.7642	.3874
Within Groups	39	.8586	.0220		
Total	40	.8754			

Levene Test for Homogeneity of Variances

Statistic	df1	df2	2-tail Sig.
7.4621	1	39	.009

Appendix 10

t-tests for independent samples of PA TOTAL

Variable	Number of Cases	Mean	SD	SE of Mean
@ADLG				
@PA 1	15	2.8500	.153	.039
@PA 2	15	2.9178	.061	.016

Mean Difference = -.0679

Levene's Test for Equality of Variances: F= 9.633 P= .004

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-1.60	28	.121	.042	(-.155, .019)
Unequal	-1.60	18.33	.126	.042	(-.157, .021)

Variable	Number of Cases	Mean	SD	SE of Mean
@AMLG				
@PA 1	15	2.7970	.340	.088
@PA 2	15	3.1417	.195	.050

Mean Difference = -.3447

Levene's Test for Equality of Variances: F= 4.690 P= .039

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-3.41	28	.002	.101	(-.552, -.138)
Unequal	-3.41	22.29	.002	.101	(-.554, -.135)

Variable	Number of Cases	Mean	SD	SE of Mean
@BCKLG				
@PA 1	15	2.6791	.512	.132
@PA 2	15	3.0827	.244	.063

Mean Difference = -.4036

Levene's Test for Equality of Variances: F= 8.470 P= .007

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-2.76	28	.010	.146	(-.704, -.103)

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Unequal	-2.76	20.02	.012	.146	(-.709, -.098)

Variable	Number of Cases	Mean	SD	SE of Mean
@EATLG				
@PA 1	15	3.9821	.176	.045
@PA 2	15	4.1061	.089	.023

Mean Difference = -.1240

Levene's Test for Equality of Variances: F= 16.420 P= .000

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	-2.43	28	.022	.051	(-.228, -.020)
Unequal	-2.43	20.73	.024	.051	(-.230, -.018)

Variable	Number of Cases	Mean	SD	SE of Mean
@PMLG				
@PA 1	15	2.8173	.717	.185
@PA 2	15	3.3189	.189	.049

Mean Difference = -.5015

Levene's Test for Equality of Variances: F= 7.113 P= .013

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	-2.62	28	.014	.191	(-.894, -.109)
Unequal	-2.62	15.94	.019	.191	(-.907, -.096)

Variable	Number of Cases	Mean	SD	SE of Mean
AUD				
@PA 1	15	.4667	.516	.133
@PA 2	13	.3077	.480	.133

Mean Difference = .1590

Levene's Test for Equality of Variances: F= 2.186 P= .151

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	.84	26	.409	.190	(-.231, .549)
Unequal	.84	25.85	.407	.188	(-.229, .547)

Appendix 10

Variable	Number of Cases	Mean	SD	SE of Mean
FB				
@PA 1	15	2.0667	.704	.182
@PA 2	15	1.4000	.632	.163

Mean Difference = .6667

Levene's Test for Equality of Variances: F= .058 P= .811

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	2.73	28	.011	.244	(.166, 1.167)
Unequal	2.73	27.69	.011	.244	(.166, 1.167)

Variable	Number of Cases	Mean	SD	SE of Mean
MEDAGE				
@PA 1	15	.4000	.507	.131
@PA 2	15	.8000	.414	.107

Mean Difference = -.4000

Levene's Test for Equality of Variances: F= 5.333 P= .029

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	-2.37	28	.025	.169	(-.746, -.054)
Unequal	-2.37	26.92	.025	.169	(-.747, -.053)

Variable	Number of Cases	Mean	SD	SE of Mean
PEDAGE				
@PA 1	15	.4667	.516	.133
@PA 2	15	.8667	.352	.091

Mean Difference = -.4000

Levene's Test for Equality of Variances: F= 15.740 P= .000

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	-2.48	28	.019	.161	(-.731, -.069)
Unequal	-2.48	24.69	.020	.161	(-.732, -.068)

Appendix 10

Variable	Number of Cases	Mean	SD	SE of Mean
PL				
@PA 1	15	.4667	.516	.133
@PA 2	15	.5333	.516	.133

Mean Difference = -.0667

Levene's Test for Equality of Variances: F= .000 P= 1.000

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-.35	28	.726	.189	(-.453, .320)
Unequal	-.35	28.00	.726	.189	(-.453, .320)

Variable	Number of Cases	Mean	SD	SE of Mean
SCH				
@PA 1	15	.5333	.516	.133
@PA 2	15	.5333	.516	.133

Mean Difference = .0000

Levene's Test for Equality of Variances: F= .000 P= 1.000

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	.00	28	1.000	.189	(-.386, .386)
Unequal	.00	28.00	1.000	.189	(-.386, .386)

Variable	Number of Cases	Mean	SD	SE of Mean
SX				
@PA 1	15	1.4667	.516	.133
@PA 2	15	1.7333	.458	.118

Mean Difference = -.2667

Levene's Test for Equality of Variances: F= 3.646 P= .067

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-1.50	28	.146	.178	(-.632, .098)
Unequal	-1.50	27.60	.146	.178	(-.632, .098)

Appendix 10

t tests for independent samples of school

Variable	Number of Cases	Mean	SD	SE of Mean
@PA2LG				
SCH 0	20	3.0090	.268	.060
SCH 1	21	3.1245	.269	.059

Mean Difference = -.1155

Levene's Test for Equality of Variances: F= .866 P= .358

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-1.38	39	.177	.084	(-.285, .054)
Unequal	-1.38	38.91	.177	.084	(-.285, .054)

Variable	Number of Cases	Mean	SD	SE of Mean
@PA1LG				
SCH 0	20	3.3704	.115	.026
SCH 1	21	3.3582	.137	.030

Mean Difference = .0122

Levene's Test for Equality of Variances: F= .050 P= .825

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	.31	39	.759	.040	(-.068, .092)
Unequal	.31	38.47	.758	.039	(-.068, .092)

Variable	Number of Cases	Mean	SD	SE of Mean
@PA3LG				
SCH 0	20	2.7719	.256	.057
SCH 1	21	2.7891	.186	.041

Mean Difference = -.0171

Levene's Test for Equality of Variances: F= 2.324 P= .135

t-test for Equality of Means					95%
Variances	t-value	df	2-Tail Sig	SE of Diff	CI for Diff
Equal	-.25	39	.807	.070	(-.158, .124)
Unequal	-.24	34.60	.809	.070	(-.160, .126)

Appendix 10

Variable	Number of Cases	Mean	SD	SE of Mean
@PA4LG				
SCH 0	20	2.9006	.143	.032
SCH 1	21	2.7812	.229	.050

Mean Difference = .1194

Levene's Test for Equality of Variances: F= 9.333 P= .004

t-test for Equality of Means

Variances	t-value	df	2-Tail Sig	SE of Diff	95% CI for Diff
Equal	1.99	39	.054	.060	(-.002, .241)
Unequal	2.01	33.80	.052	.059	(-.001, .240)

APPENDIX 11

EXPERIMENT 2

Bivariate Analyses: Correlations

Appendix 11

Correlations

Pearson's Product moment Correlation Coefficients: interrelationships between main variables

	ADLOG	AMLOG	BCKLOG	EATLOG	PMLOG
PALOG	.3300	.4977	.4605	.4508	.6345
	P= .035	P= .001	P= .002	P= .003	P= .000
ADLOG		.4390	.2130	.2277	.5818
		P= .004	P= .181	P= .152	P= .000
AMLOG			.5697	.2100	.5021
			P= .000	P= .188	P= .001
BCKLOG				.0342	.3670
				P= .832	P= .018
EATLOG					.3164
					P= .044

(Coefficient / (Cases) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

Appendix 11

Spearman Correlation Coefficients: interrelationships between variables

	PALG	ADLG	AMLG	BCKLG	EATLG	PMLG
ADLG	.1718 Sig .283					
AMLG	.4747 Sig .002	.4488 Sig .003				
BCKLG	.3547 Sig .023	.0940 Sig .559	.5262 Sig .000			
EATLG	.4579 Sig .003	.3125 Sig .047	.1714 Sig .284	-.1297 Sig .419		
PMLG	.4658 Sig .002	.4563 Sig .003	.5823 Sig .000	.3420 Sig .029	.3064 Sig .051	
AUD	-.1375 Sig .424	-.0552 Sig .749	.1835 Sig .284	-.0730 Sig .672	-.0594 Sig .731	.0674 Sig .696
FB	-.4438 Sig .004	-.2620 Sig .098	-.3864 Sig .013	-.1401 Sig .382	-.2427 Sig .126	-.4711 Sig .002
MEDAGE	.3249 Sig .038	.2490 Sig .116	.3126 Sig .047	.2605 Sig .100	.1491 Sig .352	.2789 Sig .077
PEDAGE	.4869 Sig .001	.3577 Sig .022	.4386 Sig .004	.1952 Sig .221	.3117 Sig .047	.4660 Sig .002
PL	-.0126 Sig .938	-.1524 Sig .341	-.3210 Sig .041	-.1597 Sig .319	-.0798 Sig .620	-.1678 Sig .294
SCH	.0558 Sig .729	-.2370 Sig .136	-.1613 Sig .314	.0953 Sig .554	-.0124 Sig .939	.0455 Sig .778
SX	.2684 Sig .090	.1321 Sig .410	-.0062 Sig .969	.0334 Sig .836	.4294 Sig .005	.1624 Sig .310

	AUD	FB	MEDAGE	PEDAGE	PL	SCH
FB	.1050 Sig .542					
MEDAGE	.0756 Sig .661	-.6477 Sig .000				
PEDAGE	-.0378 Sig .827	-.7071 Sig .000	.5446 Sig .000			
PL	-.0378 Sig .827	.0684 Sig .671	-.1054 Sig .512	-.2673 Sig .091		
SCH	.0125 Sig .942	.3529 Sig .024	-.3261 Sig .037	-.1805 Sig .259	.0701 Sig .663	
SX	-.2125 Sig .213	-.1426 Sig .374	-.1460 Sig .362	.0983 Sig .541	-.0462 Sig .774	.1199 Sig .455

(Coefficient / (Cases) / 2-tailed Significance)

Appendix 11

Spearman Correlation Coefficients: relationship between Phonological Awareness Test and phonological awareness subtests

PA2LOG	.2472 Sig .119			
PA3LOG	.4600 Sig .002	.5844 Sig .000		
PA4LOG	.0591 Sig .714	.1065 Sig .507	.0600 Sig .709	
PALOG	.4473 Sig .003	.8680 Sig .000	.7437 Sig .000	.3804 Sig .014
	PA1LOG	**PA2LOG**	**PA3LOG**	**PA4LOG**

(Coefficient / (Cases) / 2-tailed Significance)

Intercorrelations between individual subtests of the Phonological Awareness Test and other variables

	PA1LOG	PA2LOG	PA3LOG	PA4LOG
ADLOG	.2802 Sig .076	.1006 Sig .531	.2385 Sig .133	.0836 Sig .603
AMLOG	.2546 Sig .108	.3874 Sig .012	.3207 Sig .041	.3842 Sig .013
AUD	.0407 Sig .814	.0000 Sig 1.000	.0217 Sig .900	-.2438 Sig .152
PMLOG	.0934 Sig .561	.3267 Sig .037	.4705 Sig .002	.3626 Sig .020
EATLOG	.3209 Sig .041	.3711 Sig .017	.4422 Sig .004	.1333 Sig .406
PALOG	.4473 Sig .003	.8680 Sig .000	.7437 Sig .000	.3804 Sig .014
BCKLOG	.2936 Sig .062	.3000 Sig .057	.2472 Sig .119	.1614 Sig .313
FB	.0270 Sig .867	-.3000 Sig .057	-.4310 Sig .005	-.4451 Sig .004
MEDAGE	.1149 Sig .474	.2253 Sig .157	.3189 Sig .042	.1292 Sig .421
PEDAGE	.1528 Sig .340	.4253 Sig .006	.2901 Sig .066	.3501 Sig .025
PL	-.1996 Sig .211	.1095 Sig .496	.0845 Sig .599	-.0452 Sig .779
SX	.0631 Sig .695	.2864 Sig .070	.2747 Sig .082	-.1090 Sig .497
SCH	-.2087 Sig .190	.2324 Sig .144	-.0229 Sig .887	-.2823 Sig .074

APPENDIX 12

EXPERIMENT 2

Multivariate Analysis

Appendix 12

Multiple regression[1]

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. @PALG

Block Number 1. Method: Stepwise Criteria PIN .0500 POUT .1000
@ADLG @AMLG @BCKLG @EATLG @PMLG AUD FB MEDAGE
PEDAGE PL SCH SX

Variable(s) Entered on Step Number
1.. @PMLG

Multiple R	.62347
R Square	.38872
Adjusted R Square	.37074
Standard Error	.10538

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	.24010	.24010
Residual	34	.37757	.01111

F = 21.62089 Signif F = .0000

------------------------ Variables in the Equation ------------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
@PMLG	.155829	.033513	.623473	1.000000	1.000	4.650
(Constant)	3.946651	.104957				37.603

------ in ------

Variable	Sig T
@PMLG	.0000
(Constant)	.0000

[1] Variables names will be followed by the suffix lg. or log. to indicate transformed data

Appendix 12

Equation Number 1 Dependent Variable.. @PALG

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
@ADLG	-.093461	-.097987	.671908	1.488	.671908	-.566	.5755
@AMLG	.215302	.239544	.756688	1.322	.756688	1.417	.1658
@BCKLG	.250650	.300084	.876174	1.141	.876174	1.807	.0799
@EATLG	.277995	.338817	.908026	1.101	.908026	2.069	.0465
AUD	-.027102	-.034631	.998059	1.002	.998059	-.199	.8434
FB	-.229439	-.271796	.857812	1.166	.857812	-1.622	.1142
MEDAGE	.171874	.201745	.842220	1.187	.842220	1.183	.2452
PEDAGE	.259176	.303045	.835734	1.197	.835734	1.827	.0768
PL	.079066	.100391	.985472	1.015	.985472	.580	.5661
SCH	.127762	.161939	.982059	1.018	.982059	.943	.3527
SX	.195188	.249215	.996520	1.003	.996520	1.478	.1488

Variable(s) Entered on Step Number
2.. @EATLG

Multiple R	.67742
R Square	.45889
Adjusted R Square	.42610
Standard Error	.10064

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	2	.28345	.14172
Residual	33	.33423	.01013

F = 13.99300 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
@EATLG	.242632	.117286	.277995	.908026	1.101	2.069
@PMLG	.134757	.033587	.539165	.908026	1.101	4.012
(Constant)	3.029568	.454500				6.666

----- in -----

Variable	Sig T
@EATLG	.0465
@PMLG	.0003
(Constant)	.0000

Appendix 12

Equation Number 1 Dependent Variable.. @PALG

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
@ADLG	-.091782	-.102274	.671890	1.488	.628173	-.582	.5649
@AMLG	.189618	.223335	.750653	1.332	.717492	1.296	.2042
@BCKLG	.273390	.346907	.871255	1.148	.792383	2.092	.0444
AUD	-.017784	-.024138	.996820	1.003	.906900	-.137	.8922
FB	-.142560	-.166529	.738361	1.354	.738361	-.955	.3466
MEDAGE	.094134	.112091	.767251	1.303	.767251	.638	.5279
PEDAGE	.188939	.223862	.759631	1.316	.759631	1.299	.2031
PL	.062649	.084381	.981630	1.019	.891798	.479	.6352
SCH	.159797	.213914	.969673	1.031	.896575	1.239	.2244
SX	.099769	.122323	.813410	1.229	.741177	.697	.4907

Equation Number 1 Dependent Variable.. @PALG

Variable(s) Entered on Step Number
3.. @BCKLG

Multiple R	.72389
R Square	.52401
Adjusted R Square	.47939
Standard Error	.09585

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	3	.32367	.10789
Residual	32	.29401	.00919

F = 11.74285 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
@BCKLG	.088238	.042172	.273390	.871255	1.148	2.092
@EATLG	.260194	.112023	.298117	.902929	1.108	2.323
@PMLG	.109187	.034244	.436860	.792383	1.262	3.189
(Constant)	2.784998	.448388				6.211

------ in ------

Variable	Sig T
@BCKLG	.0444
@EATLG	.0267
@PMLG	.0032
(Constant)	.0000

Appendix 12

Equation Number 1 Dependent Variable.. @PALG

---------------------- Variables not in the Equation ----------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
@ADLG	-.090767	-.107839	.671883	1.488	.569967	-.604	.5503
@AMLG	.069878	.078106	.594675	1.682	.594675	.436	.6657
AUD	.015731	.022572	.979952	1.020	.792147	.126	.9008
FB	-.115976	-.143821	.731990	1.366	.731990	-.809	.4246
MEDAG	.059927	.075530	.756130	1.323	.736996	.422	.6761
PEDAGE	.187599	.236990	.759615	1.316	.717676	1.358	.1842
PL	.063865	.091714	.981609	1.019	.780320	.513	.6117
SCH	.129094	.182777	.954171	1.048	.778144	1.035	.3086
SX	.032201	.040804	.764316	1.308	.718248	.227	.8216

End Block Number 1 PIN = .050 Limits reached.

Equation Number 1 Dependent Variable.. @PALG

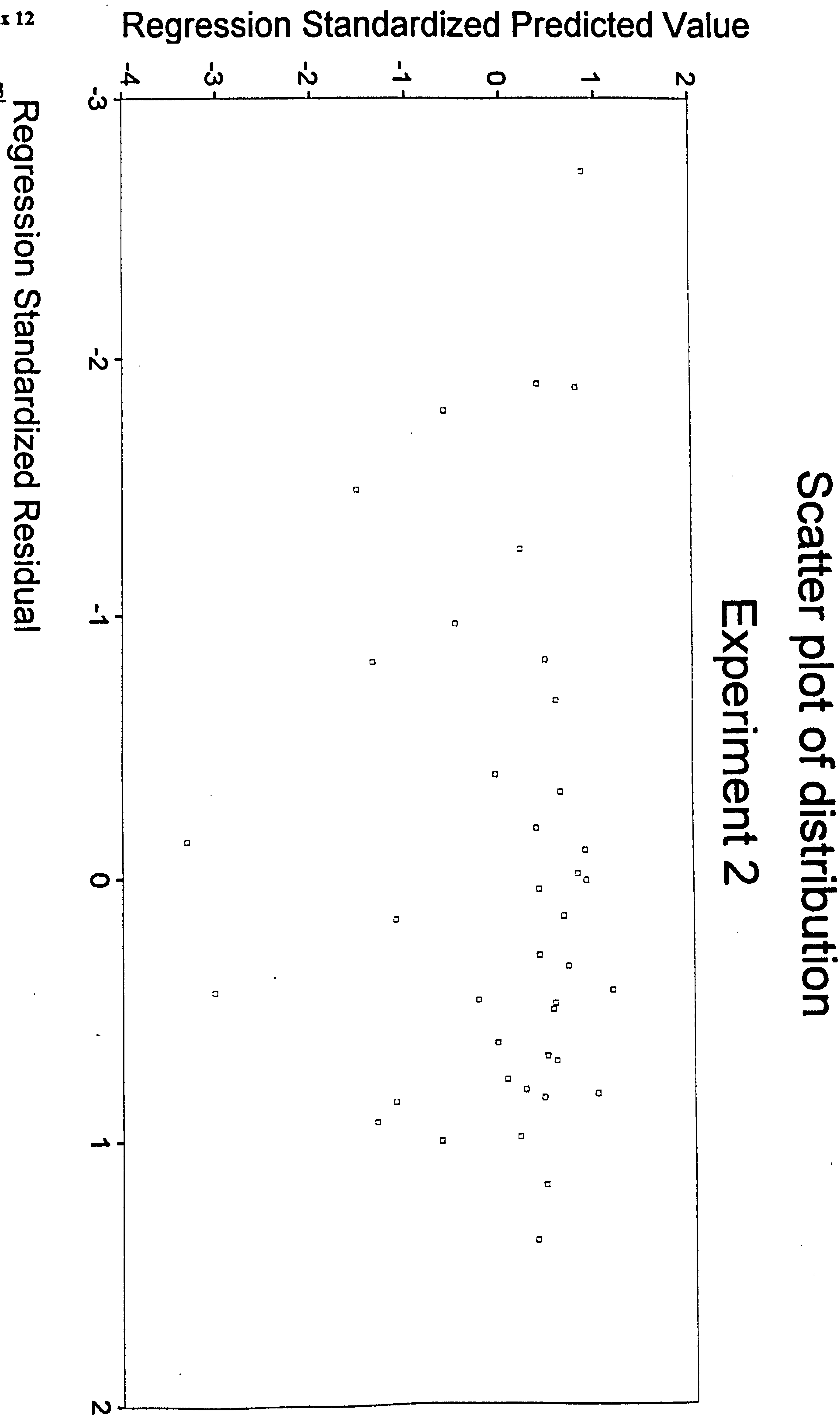
Residuals Statistics:

	Min	Max	Mean	Std Dev	N
*PRED	4.1248	4.5413	4.4356	.0928	41
*RESID	-.2406	.1253	.0025	.0865	41
*ZPRED	-3.1508	1.1806	.0806	.9655	41
*ZRESID	-2.5101	1.3072	.0264	.9029	41

Total Cases = 41

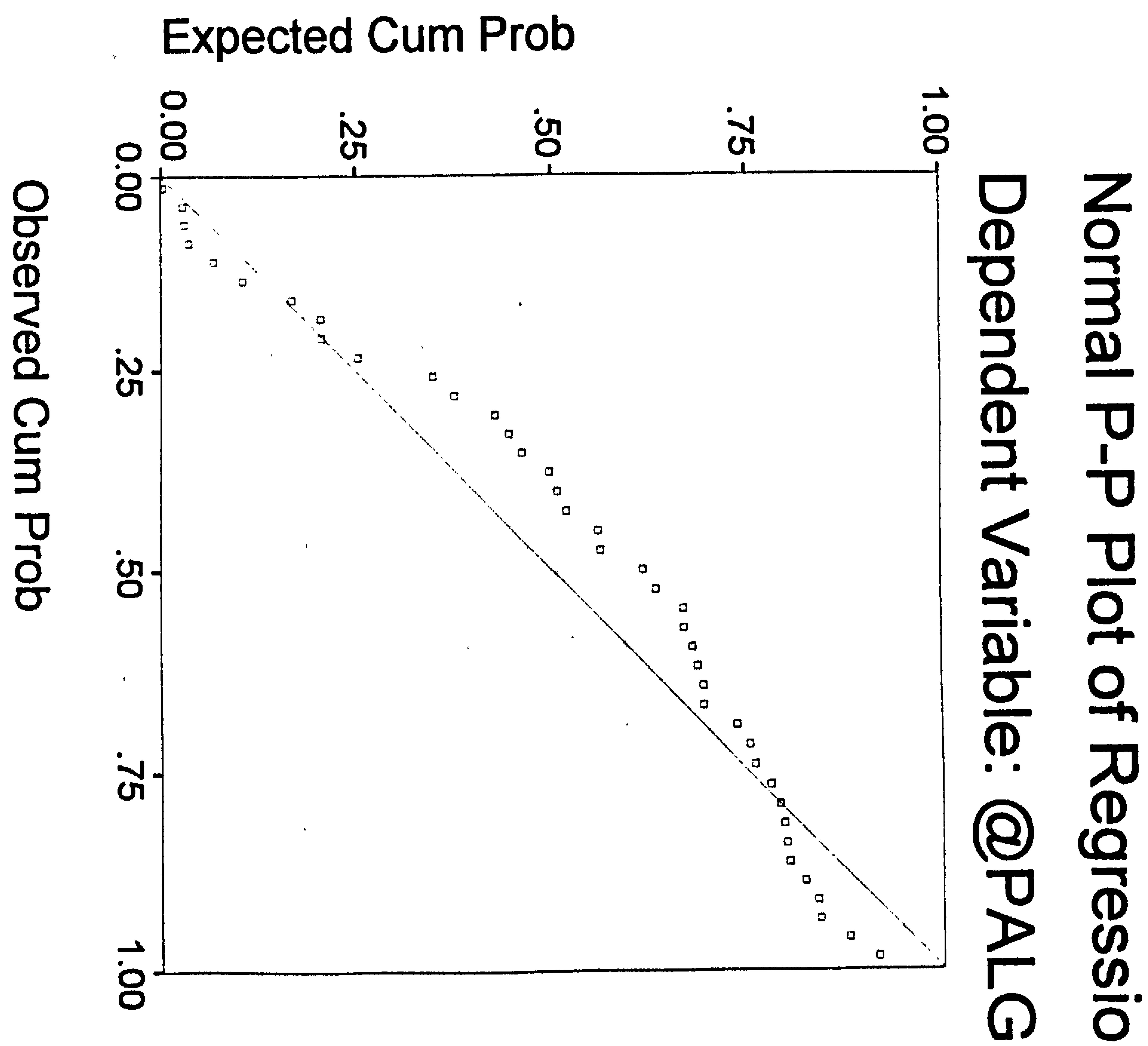
Appendix 12

Figure 3



Appendix 12

<u>Figure 4</u>



Appendix 12

Stepwise multiple regression **Dependent variable: subtest pa1 (at five)**
Independent variables: Test scores at five

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. @PA1LG

Block Number 1. Method: Stepwise Criteria PIN .0500 POUT .1000
@ADLG @AMLG @BCKLG @EATLG @PA2LG @PA3LG @PA4LG @PMLG
AUD FB MEDAGE PEDAGE PL SCH ST SX

Variable(s) Entered on Step Number
1.. @PMLG

Multiple R	.66927
R Square	.44792
Adjusted R Square	.43168
Standard Error	.10031

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	.27754	.27754
Residual	34	.34208	.01006

F = 27.58529 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
@PMLG	.167539	.031899	.669268	1.000000	1.000	5.252
(Constant)	2.841678	.099903				28.444

----- in -----

Variable	Sig T
@PMLG	.0000
(Constant)	.0000

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
@ADLG	.007211	.007955	.671908	1.488	.671908	.046	.9638
@AMLG	-.179958	-.210682	.756688	1.322	.756688	-1.238	.2244
@BCKLG	.079333	.099942	.876174	1.141	.876174	.577	.5678
@EATLG	.011642	.014931	.908026	1.101	.908026	.086	.9322
@PA2LG	.004977	.006522	.948098	1.055	.948098	.037	.9703
@PA3LG	.157946	.193485	.828480	1.207	.828480	1.133	.2654
@PA4LG	-.150417	-.173235	.732286	1.366	.732286	-1.010	.3196
AUD	-.024930	-.033519	.998059	1.002	.998059	-.193	.8484
FB	.211056	.263082	.857812	1.166	.857812	1.566	.1268
MEDAGE	.012878	.015906	.842220	1.187	.842220	.091	.9277
PEDAGE	.025194	.030998	.835734	1.197	.835734	.178	.8597
PL	-.164524	-.219811	.985472	1.015	.985472	-1.294	.2045
SCH	.065606	.087500	.982059	1.018	.982059	.505	.6172
ST	-.007946	-.010646	.990849	1.009	.990849	-.061	.9516
SX	-.020929	-.028119	.996520	1.003	.996520	-.162	.8726

Appendix 12

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	@PMLG
1	1.98590	1.000	.00705	.00705
2	.01410	11.868	.99295	.99295

End Block Number 1 PIN = .050 Limits reached.

Residuals Statistics:

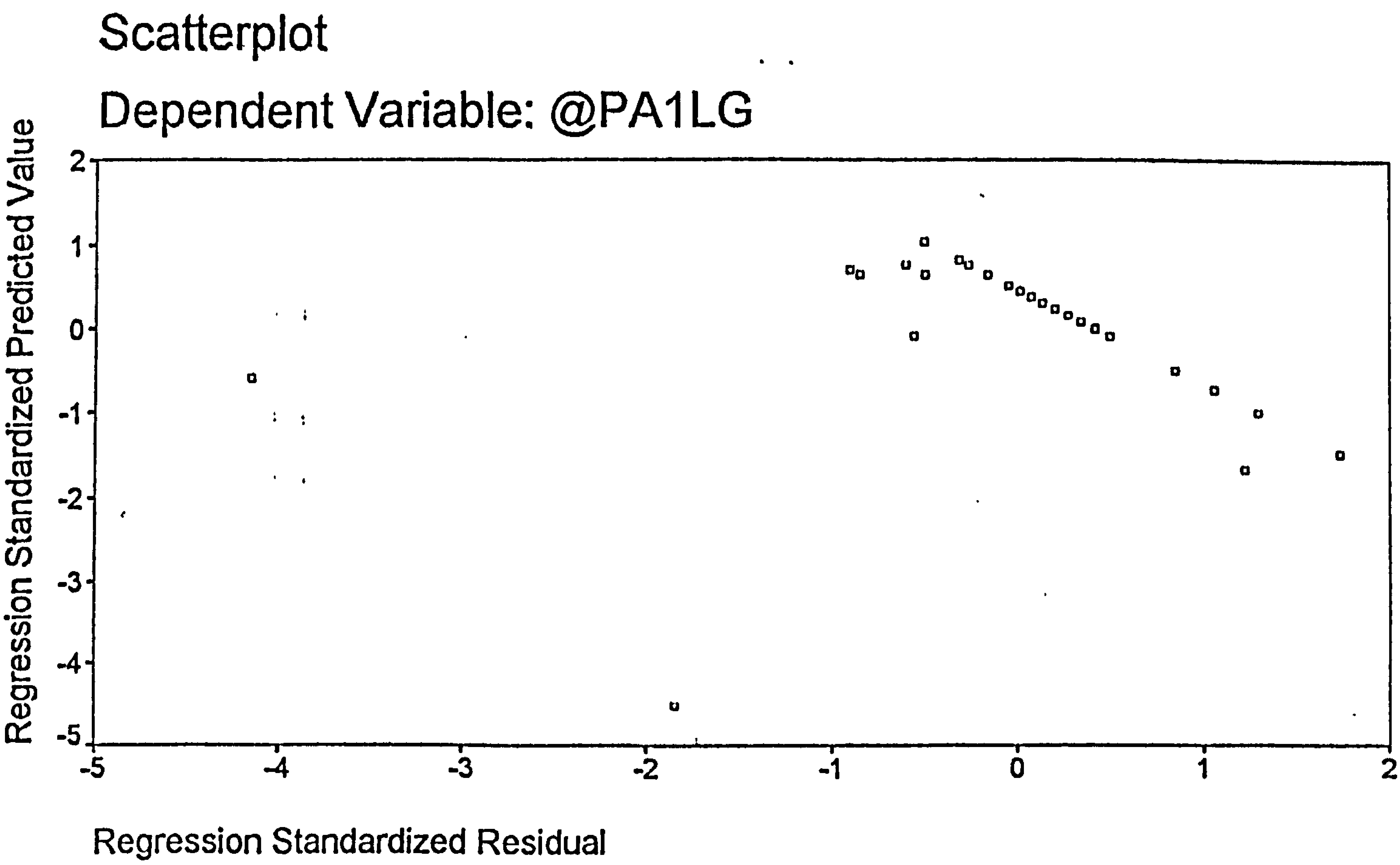
	Min	Max	Mean	Std Dev	N
*PRED	2.9578	3.4511	3.3637	.0845	41
*RESID	-.4158	.1737	.0004	.0927	41
*ZPRED	-4.5051	1.0346	.0531	.9492	41
*ZRESID	-4.1456	1.7322	.0042	.9242	41

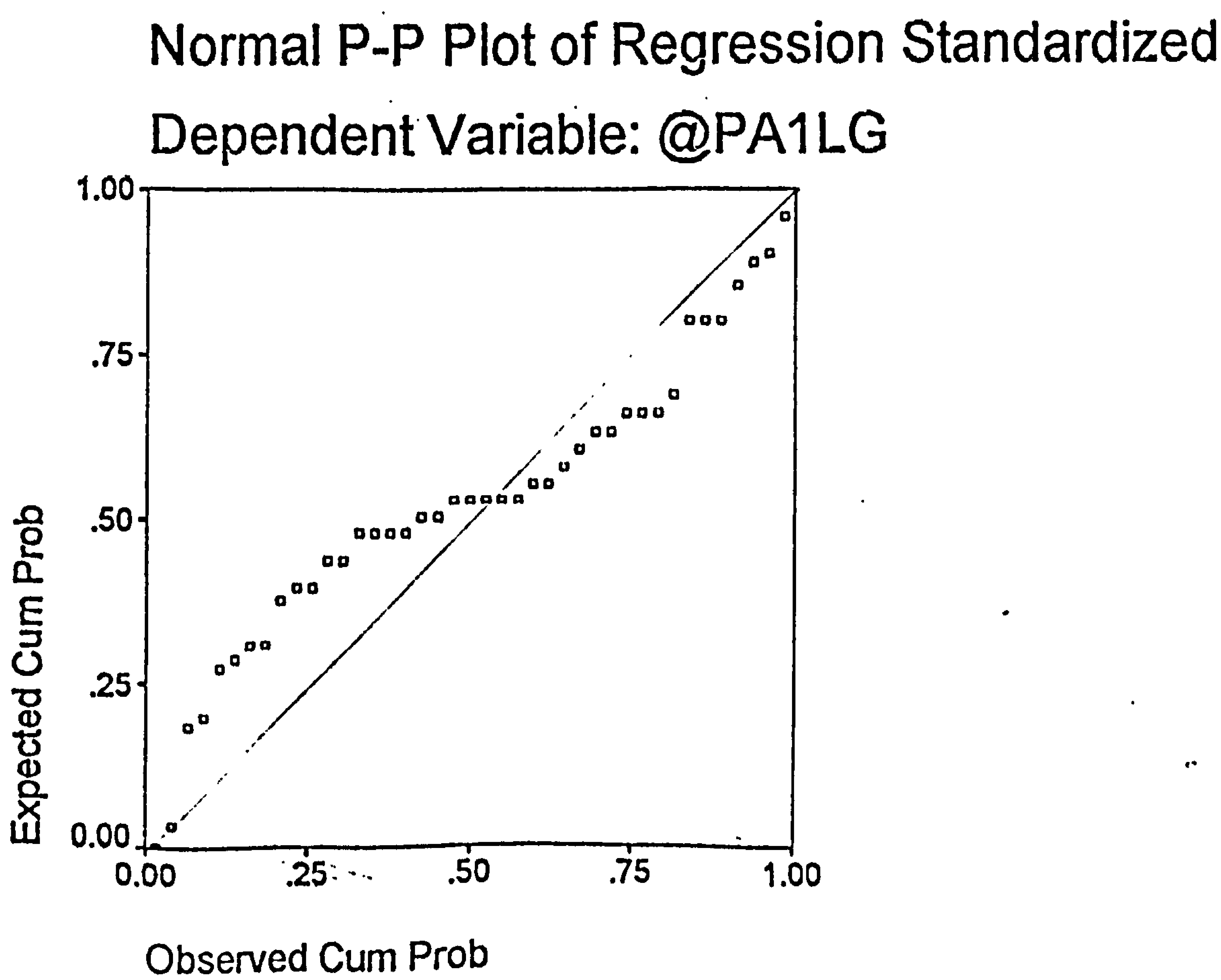
Total Cases = 41

Hi-Res Chart # 12:Normal p-p plot of *zresid

Hi-Res Chart # 11:Scatterplot of *zpred with *zresid

Appendix 12


Scatterplot
Dependent Variable: @PA1LG
Regression Standardized Predicted Value
2
1
0
-1
-2
-3
-4
-5
-5
-4
-3
-2
-1
0
1
2
Regression Standardized Residual


Normal P-P Plot of Regression Standardized
Dependent Variable: @PA1LG
Expected Cum Prob
1.00
.75
.50
.25
0.00
0.00
.25
.50
.75
1.00
Observed Cum Prob

Appendix 12

Stepwise multiple regression

Dependent variable: subtest pa2 (at five)
Independent variables: Test scores at five

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. @PA2LG

Block Number 1. Method: Stepwise Criteria PIN .0500 POUT .1000
@ADLG @AMLG @BCKLG @EATLG @PA3LG @PA4LG @PMLG AUD
FB MEDAGE PEDAGE PL SCH ST SX @PA1LG

Variable(s) Entered on Step Number
1.. @PA3LG

Multiple R	.64133
R Square	.41130
Adjusted R Square	.39398
Standard Error	.21762

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	1.12501	1.12501
Residual	34	1.61025	.04736

F = 23.75424 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
@PA3LG	.790229	.162137	.641326	1.000000	1.000	4.874
(Constant)	.859788	.449470				1.913

------ in ------

Variable	Sig T
@PA3LG	.0000
(Constant)	.0642

---------- --------- Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
@ADLG	-.116367	-.147424	.944873	1.058	.944873	-.856	.3980
@AMLG	.036859	.043852	.833269	1.200	.833269	.252	.8025
@BCKLG	.183159	.230850	.935182	1.069	.935182	1.363	.1821
@EATLG	-.077381	-.084924	.709076	1.410	.709076	-.490	.6276
@PA4LG	.034720	.044854	.982476	1.018	.982476	.258	.7981
@PMLG	-.045607	-.054104	.828480	1.207	.828480	-.311	.7576
AUD	.010372	.013515	.999477	1.001	.999477	.078	.9386
FB	.038376	.042890	.735368	1.360	.735368	.247	.8067
MEDAGE	-.070739	-.082427	.799322	1.251	.799322	-.475	.6378
PEDAGE	.141342	.171011	.861791	1.160	.861791	.997	.3260
PL	.153166	.199579	.999532	1.000	.999532	1.170	.2504
SCH	.223696	.290340	.991732	1.008	.991732	1.743	.0907
ST	.120277	.153662	.960858	1.041	.960858	.893	.3782
SX	.129268	.159196	.892846	1.120	.892846	.926	.3610
@PA1LG	-.125362	-.149167	.833510	1.200	.833510	-.867	.3924

Appendix 12

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	@PA3LG
1	1.99674	1.000	.00163	.00163
2	.00326	24.744	.99837	.99837

End Block Number 1 PIN = .050 Limits reached.

Residuals Statistics:

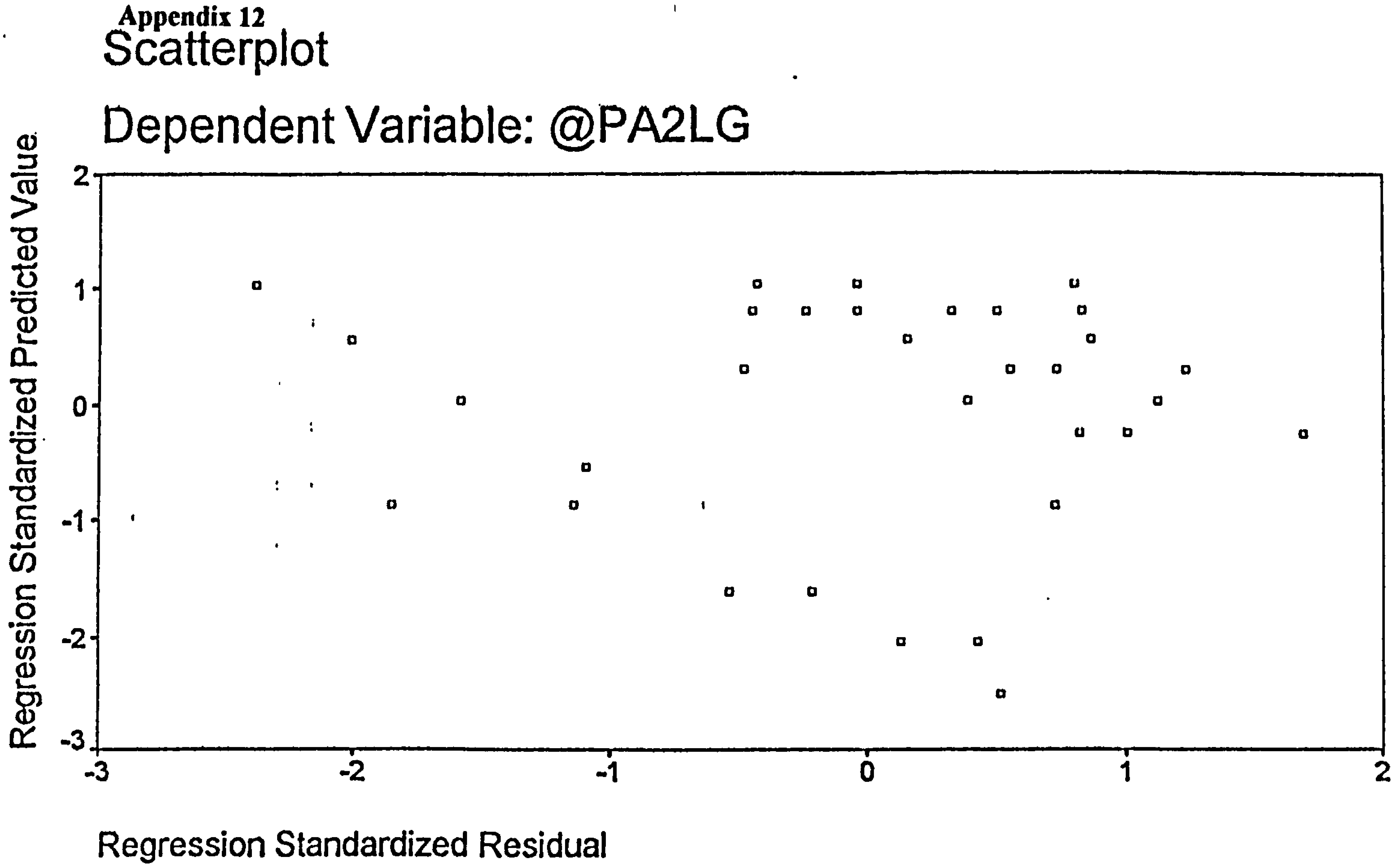
	Min	Max	Mean	Std Dev	N
*PRED	2.5961	3.2271	3.0572	.1742	41
*RESID	-.5191	.3675	.0110	.2062	41
*ZPRED	-2.4943	1.0253	.0776	.9718	41
*ZRESID	-2.3851	1.6888	.0504	.9475	41

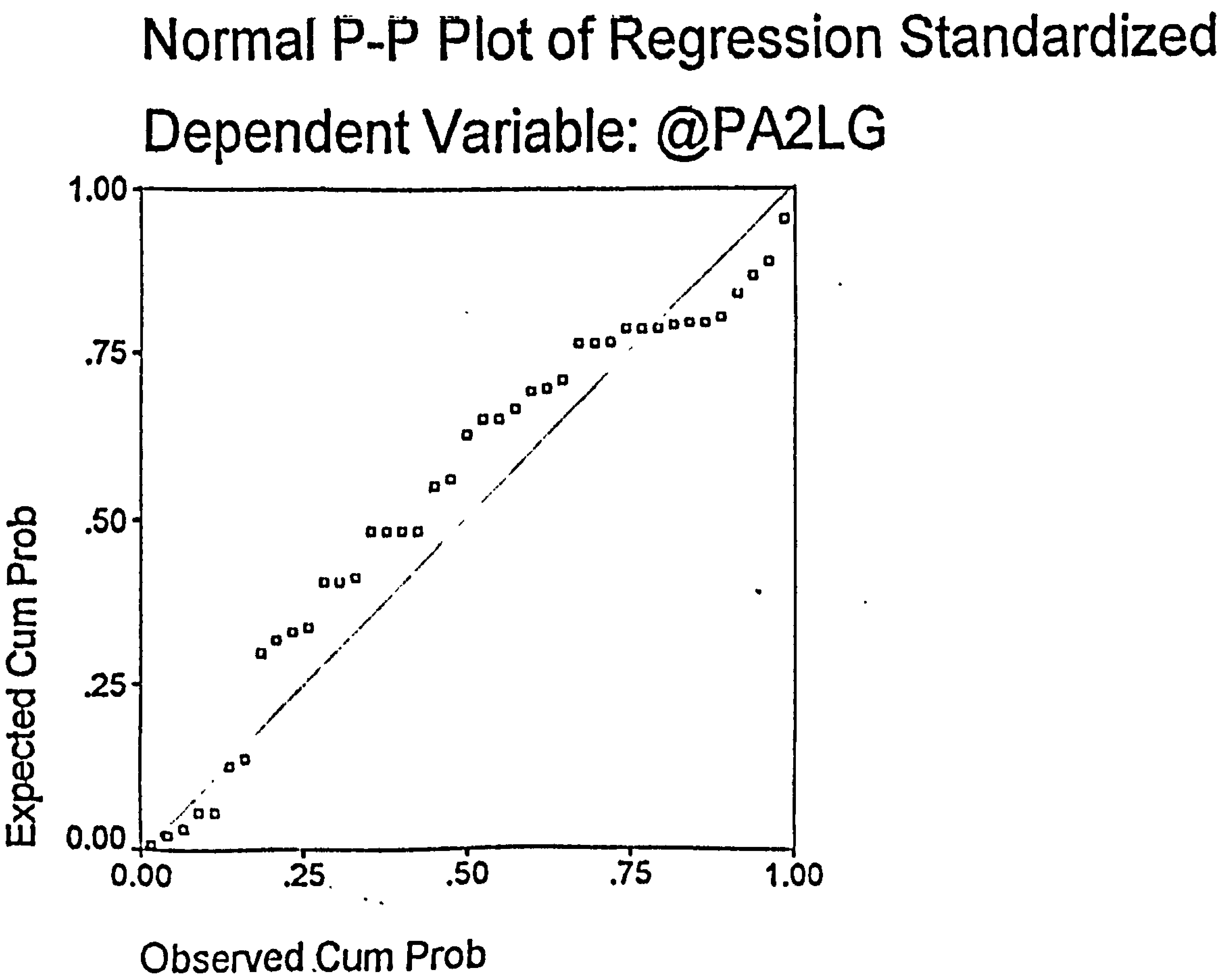
Total Cases = 41

Hi-Res Chart # 14:Normal p-p plot of *zresid

Hi-Res Chart # 13:Scatterplot of *zpred with *zresid

Appendix 12


Scatterplot
Dependent Variable: @PA2LG
Regression Standardized Predicted Value
2
1
0
-1
-2
-3
-3
-2
-1
0
1
2
Regression Standardized Residual


Normal P-P Plot of Regression Standardized
Dependent Variable: @PA2LG
Expected Cum Prob
1.00
.75
.50
.25
0.00
0.00
.25
.50
.75
1.00
Observed Cum Prob

Appendix 12

Stepwise multiple regression

Dependent variable: subtest pa3 (at five)
Independent variables: Test scores at five

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. @PA3LG

Block Number 1. Method: Stepwise Criteria PIN .0500 POUT .1000
@ADLG @AMLG @BCKLG @EATLG @PA4LG @PMLG AUD FB
MEDAGE PEDAGE PL . SCH ST SX @PA1LG @PA2LG

Variable(s) Entered on Step Number
1.. @PA2LG

Multiple R	.64133
R Square	.41130
Adjusted R Square	.39398
Standard Error	.17662

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	.74098	.74098
Residual	34	1.06058	.03119

F = 23.75424 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
@PA2LG	.520480	.106791	.641326	1.000000	1.000	4.874
(Constant)	1.179150	.326325				3.613

----- in -----

Variable	Sig T
@PA2LG	.0000
(Constant)	.0010

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
@ADLG	.209083	.272277	.998349	1.002	.998349	1.626	.1136
@AMLG	.241345	.300786	.914395	1.094	.914395	1.812	.0791
@BCKLG	.045074	.055360	.888066	1.126	.888066	.319	.7521
@EATLG	.385362	.480508	.915293	1.093	.915293	3.147	.0035
@PA4LG	.056860	.073581	.985837	1.014	.985837	.424	.6744
@PMLG	.282716	.358781	.948098	1.055	.948098	2.208	.0343
AUD	.006823	.008890	.999373	1.001	.999373	.051	.9596
FB	-.353077	-.438733	.908981	1.100	.908981	-2.805	.0084
MEDAGE	.316855	.401820	.946753	1.056	.946753	2.521	.0167
PEDAGE	.161727	.196631	.870235	1.149	.870235	1.152	.2576
PL	-.087893	-.112945	.972120	1.029	.972120	-.653	.5183
SCH	-.096303	-.120488	.921509	1.085	.921509	-.697	.4905
ST	.044998	.056897	.941217	1.062	.941217	.327	.7454
SX	.132739	.163589	.894147	1.118	.894147	.953	.3477
@PA1LG	.315005	.405450	.975291	1.025	.975291	2.548	.0157

Appendix 12

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	@PA2LG
1	1.99592	1.000	.00204	.00204
2	.00408	22.127	.99796	.99796

Variable(s) Entered on Step Number
2.. @EATLG

Multiple R	.73975
R Square	.54722
Adjusted R Square	.51978
Standard Error	.15722

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	2	.98586	.49293
Residual	33	.81571	.02472

F = 19.94177 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
@EATLG	.574413	.182499	.385362	.915293	1.093	3.147
@PA2LG	.429457	.099364	.529168	.915293	1.093	4.322
(Constant)	-.868997	.712620				-1.219

------ in ------

Variable	Sig T
@EATLG	.0035
@PA2LG	.0001
(Constant)	.2313

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
@ADLG	.152315	.223069	.971136	1.030	.890343	1.294	.2048
@AMLG	.187281	.263079	.893448	1.119	.860812	1.543	.1328
@BCKLG	.070305	.098262	.884456	1.131	.810826	.559	.5804
@PA4LG	-.004272	-.006217	.959216	1.043	.890578	-.035	.9722
@PMLG	.199296	.278905	.886749	1.128	.856066	1.643	.1102
AUD	.027806	.041244	.996166	1.004	.912355	.234	.8169
FB	-.238507	-.311153	.770601	1.298	.770601	-1.852	.0733
MEDAGE	.213256	.290276	.838886	1.192	.811010	1.716	.0958
PEDAGE	.041421	.054505	.783998	1.276	.783998	.309	.7595
PL	-.077611	-.113678	.971376	1.029	.889544	-.647	.5221
SCH	-9.267E-04	-.001281	.864610	1.157	.808769	-.007	.9943
ST	.045630	.065790	.941215	1.062	.865611	.373	.7116
SX	-.011429	-.014947	.774476	1.291	.774476	-.085	.9331
@PA1LG	.256806	.370912	.944531	1.059	.886425	2.259	.0308

Appendix 12

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	@EATLG	@PA2LG
1	2.99430	1.000	.00015	.00014	.00083
2	.00502	24.423	.05093	.03623	.98834
3	.00068	66.350	.94892	.96363	.01083

Variable(s) Entered on Step Number
3.. @PA1LG

Multiple R	.78071
R Square	.60951
Adjusted R Square	.57291
Standard Error	.14827

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	3	1.09808	.36603
Residual	32	.70349	.02198

F = 16.64971 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
@EATLG	.504240	.174889	.338284	.886425	1.128	2.883
@PA1LG	.437889	.193811	.256806	.944531	1.059	2.259
@PA2LG	.407816	.094196	.502502	.905828	1.104	4.329
(Constant)	-1.989946	.835344				-2.382

----- in ------

Variable	Sig T
@EATLG	.0070
@PA1LG	.0308
@PA2LG	.0001
(Constant)	.0233

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
@ADLG	.068268	.100086	.839300	1.191	.816307	.560	.5795
@AMLG	.154804	.232066	.877539	1.140	.856945	1.328	.1938
@BCKLG	-.006594	-.009504	.811244	1.233	.810825	-.053	.9581
@PA4LG	-.057068	-.087665	.921471	1.085	.871398	-.490	.6276
@PMLG	.048642	.056034	.518186	1.930	.518186	.312	.7568
AUD	.040376	.064409	.993688	1.006	.884468	.359	.7218
FB	-.252880	-.354826	.768791	1.301	.750197	-2.113	.0427
MEDAGE	.164218	.235566	.803502	1.245	.802539	1.350	.1869
PEDAGE	-.019817	-.027429	.748084	1.337	.748084	-.153	.8796
PL	-.008385	-.012712	.897439	1.114	.869203	-.071	.9440
SCH	.007224	.010745	.863814	1.158	.799701	.060	.9527
ST	.040647	.063095	.940859	1.063	.857885	.352	.7272
SX	.019705	.027585	.765282	1.307	.759594	.154	.8789

Appendix 12

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	@EATLG	@PA1LG	@PA2LG
1	3.99263	1.000	.00005	.00008	.00009	.00046
2	.00566	26.556	.01463	.01167	.02641	.97270
3	.00113	59.554	.00693	.50218	.66931	.01808
4	.00058	83.112	.97838	.48608	.30419	.00876

Variable(s) Entered on Step Number
4.. FB

Multiple R	.81159
R Square	.65868
Adjusted R Square	.61463
Standard Error	.14084

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	4	1.18665	.29666
Residual	31	.61492	.01984

F = 14.95574 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
@EATLG	.354651	.180580	.237928	.750197	1.333	1.964
FB	-.078386	.037096	-.252880	.768791	1.301	-2.113
@PA1LG	.456763	.184316	.267875	.942313	1.061	2.478
@PA2LG	.368192	.091420	.453678	.867717	1.152	4.027
(Constant)	-1.190066	.879154				-1.354

----- in -----

Variable	Sig T
@EATLG	.0586
FB	.0427
@PA1LG	.0189
@PA2LG	.0003
(Constant)	.1856

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
@ADLG	-.004426	-.006624	.764403	1.308	.700187	-.036	.9713
@AMLG	.074673	.110483	.747192	1.338	.654597	.609	.5472
@BCKLG	-.043655	-.066573	.793778	1.260	.729407	-.365	.7173
@PA4LG	-.144457	-.225199	.829503	1.206	.692061	-1.266	.2153
@PMLG	-.081450	-.092686	.441987	2.263	.441987	-.510	.6139
AUD	.057517	.097857	.988012	1.012	.750057	.539	.5942
MEDAGE	.044388	.057495	.572662	1.746	.547923	.315	.7546
PEDAGE	-.294495	-.340664	.456733	2.189	.456733	-1.985	.0564
PL	.034837	.055567	.868410	1.152	.743784	.305	.7626
SCH	.113078	.166651	.741357	1.349	.659806	.926	.3620
ST	.073903	.121504	.922625	1.084	.748298	.670	.5077
SX	.019223	.028784	.765279	1.307	.657633	.158	.8757

Appendix 12

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	@EATLG	FB	@PA1LG	@PA2LG
1	4.86604	1.000	.00003	.00004	.00423	.00006	.00029
2	.12725	6.184	.00017	.00041	.71247	.00040	.00399
3	.00516	30.716	.01146	.01729	.07092	.02857	.99194
4	.00108	67.278	.02144	.34915	.03208	.80413	.00372
5	.00048	100.821	.96690	.63311	.18030	.16685	.00005

End Block Number 1 PIN = .050 Limits reached.

Residuals Statistics:

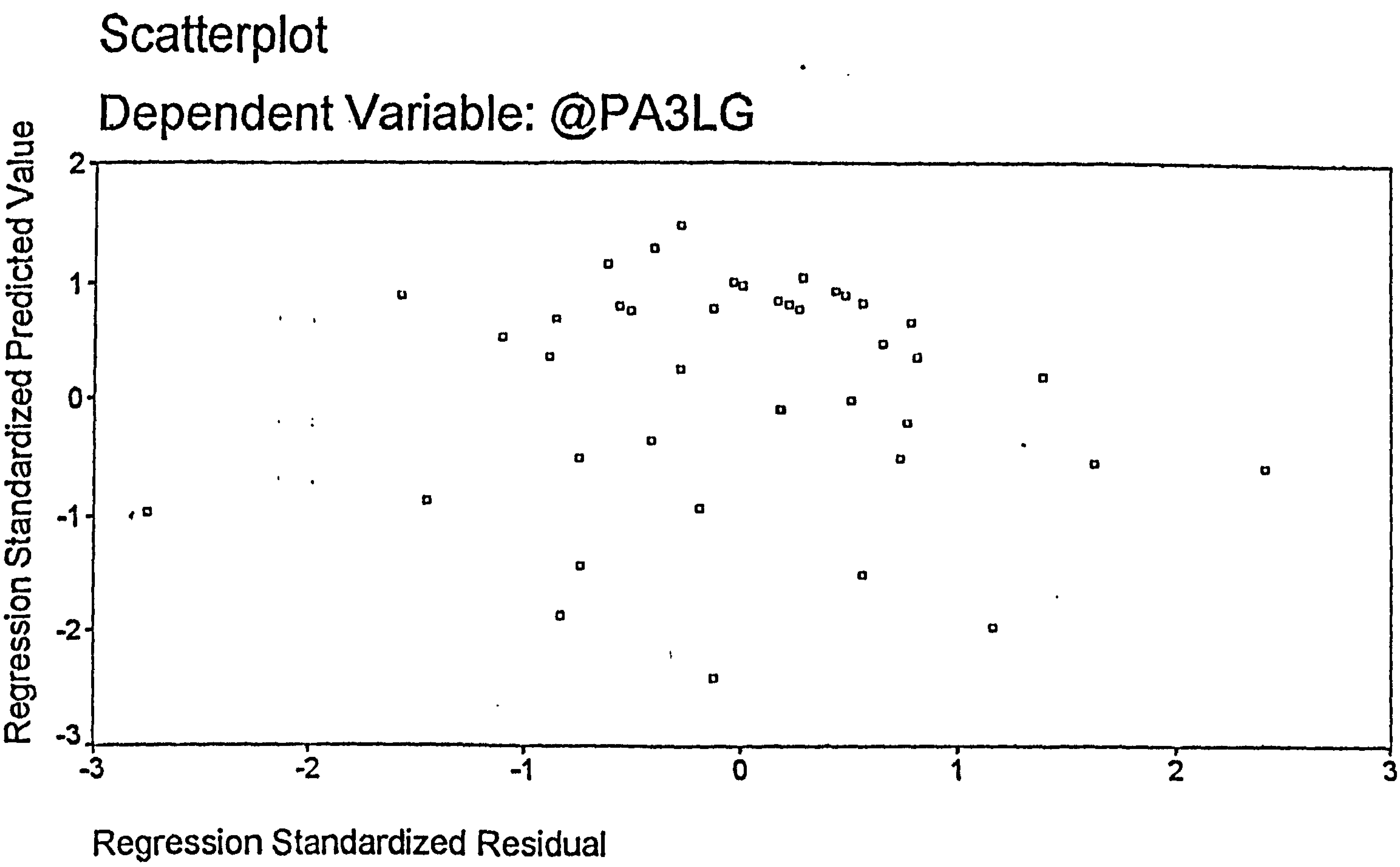
	Min	Max	Mean	Std Dev	N
*PRED	2.3198	3.0338	2.7812	.1795	41
*RESID	-.3868	.3399	-.0005	.1302	41
*ZPRED	-2.4077	1.4702	.0984	.9748	41
*ZRESID	-2.7464	2.4132	-.0037	.9243	41

Total Cases = 41

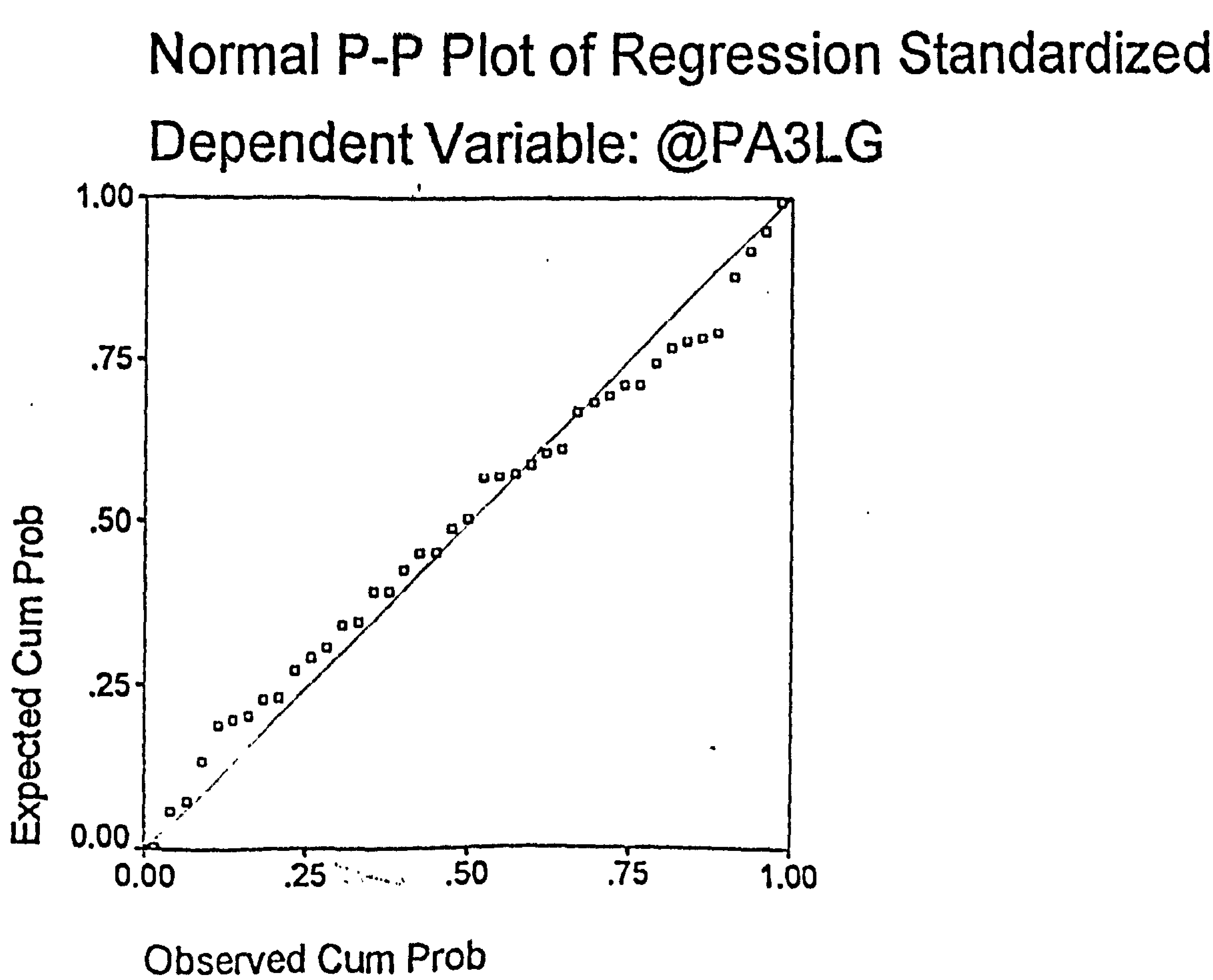
Hi-Res Chart # 16:Normal p-p plot of *zresid

Hi-Res Chart # 15:Scatterplot of *zpred with *zresid

Appendix 12



Scatterplot
Dependent Variable: @PA3LG
Regression Standardized Predicted Value
2
1
0
-1
-2
-3
-3
-2
-1
0
1
2
3
Regression Standardized Residual



Normal P-P Plot of Regression Standardized
Dependent Variable: @PA3LG
Expected Cum Prob
1.00
.75
.50
.25
0.00
0.00
.25
.50
.75
1.00
Observed Cum Prob

Appendix 12

Stepwise multiple regression **Dependent variable: subtest pa4 (at five)**
Independent variables: Test scores at five

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. @PA4LG

Block Number 1. Method: Stepwise Criteria PIN .0500 POUT .1000
@ADLG @AMLG @BCKLG @EATLG @PMLG AUD FB MEDAGE
PEDAGE PL SCH ST SX @PA1LG @PA2LG @PA3LG

Variable(s) Entered on Step Number
1.. @PMLG

Multiple R	.51741
R Square	.26771
Adjusted R Square	.24618
Standard Error	.17411

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	.37679	.37679
Residual	34	1.03066	.03031

F = 12.42992 Signif F = .0012

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
@PMLG	.195210	.055369	.517410	1.000000	1.000	3.526
(Constant)	2.239893	.173408				12.917

------ in ------

Variable	Sig T
@PMLG	.0012
(Constant)	.0000

Equation Number 1 Dependent Variable.. @PA4LG

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
@ADLG	-.165104	-.158151	.671908	1.488	.671908	-.920	.3642
@AMLG	.124052	.126102	.756688	1.322	.756688	.730	.4704
@BCKLG	.065106	.071216	.876174	1.141	.876174	.410	.6843
@EATLG	.037240	.041469	.908026	1.101	.908026	.238	.8130
AUD	-.207036	-.241704	.998059	1.002	.998059	-1.431	.1619
FB	-.185510	-.200781	.857812	1.166	.857812	-1.177	.2475
MEDAGE	-.042080	-.045128	.842220	1.187	.842220	-.260	.7969
PEDAGE	.024438	.026108	.835734	1.197	.835734	.150	.8817
PL	.014601	.016938	.985472	1.015	.985472	.097	.9231
SCH	-.344930	-.399447	.982059	1.018	.982059	-2.503	.0174
ST	-.340108	-.395622	.990849	1.009	.990849	-2.475	.0187
SX	-.184350	-.215053	.996520	1.003	.996520	-1.265	.2147
@PA1LG	-.199515	-.173235	.552080	1.811	.552080	-1.010	.3196
@PA2LG	.001196	.001361	.948098	1.055	.948098	.008	.9938
@PA3LG	-.098863	-.105156	.828480	1.207	.828480	-.607	.5477

Appendix 12

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	@PMLG
1	1.98590	1.000	.00705	.00705
2	.01410	11.868	.99295	.99295

Variable(s) Entered on Step Number
2.. SCH

Multiple R	.62013
R Square	.38456
Adjusted R Square	.34726
Standard Error	.16201

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	2	.54124	.27062
Residual	33	.86621	.02625

F = 10.30989 Signif F = .0003

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
@PMLG	.177779	.051992	.471209	.982059	1.018	3.419
SCH	-.137254	.054836	-.344930	.982059	1.018	-2.503
(Constant)	2.369967	.169525				13.980

----- in -----

Variable	Sig T
@PMLG	.0017
SCH	.0174
(Constant)	.0000

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
@ADLG	-.257007	-.263298	.645945	1.548	.645945	-1.544	.1324
@AMLG	.071113	.078096	.742241	1.347	.742241	.443	.6607
@BCKLG	.116006	.137171	.860511	1.162	.850098	.783	.4392
@EATLG	-.003083	-.003721	.896575	1.115	.896575	-.021	.9833
AUD	-.204765	-.260753	.998015	1.002	.980262	-1.528	.1364
FB	-.088279	-.099975	.789331	1.267	.789331	-.568	.5737
MEDAGE	-.155821	-.175308	.779002	1.284	.779002	-1.007	.3214
PEDAGE	-.031858	-.036711	.817260	1.224	.817260	-.208	.8367
PL	.063055	.079035	.966903	1.034	.963554	.448	.6568
ST	-.283659	-.352926	.952717	1.050	.944265	-2.134	.0406
SX	-.148771	-.188178	.984664	1.016	.970375	-1.084	.2865
@PA1LG	-.160490	-.151421	.547853	1.825	.538366	-.867	.3926
@PA2LG	.127435	.149746	.849814	1.177	.849814	.857	.3980
@PA3LG	-.038934	-.044574	.806654	1.240	.798787	-.252	.8023

Appendix 12

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	@PMLG	SCH
1	2.64037	1.000	.00346	.00369	.04715
2	.34626	2.761	.00872	.01333	.89893
3	.01337	14.054	.98782	.98298	.05392

Variable(s) Entered on Step Number
3.. ST

Multiple R	.67913
R Square	.46121
Adjusted R Square	.41070
Standard Error	.15394

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	3	.64914	.21638
Residual	32	.75832	.02370

F = 9.13090 Signif F = .0002

------------------------ Variables in the Equation ------------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
@PMLG	.190841	.049778	.505830	.967206	1.034	3.834
SCH	-.115012	.053135	-.289035	.944265	1.059	-2.165
ST	-.033994	.015931	-.283659	.952717	1.050	-2.134
(Constant)	2.328611	.162238				14.353

------ in -------

Variable	Sig T
@PMLG	.0006
SCH	.0380
ST	.0406
(Constant)	.0000

---------------------- Variables not in the Equation ----------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
@ADLG	-.258578	-.283124	.645932	1.548	.645932	-1.644	.1104
@AMLG	.104556	.122095	.734705	1.361	.734705	.685	.4985
@BCKLG	.171939	.214106	.835457	1.197	.835457	1.220	.2315
@EATLG	.016257	.020926	.892681	1.120	.890978	.117	.9080
AUD	-.155583	-.207477	.958139	1.044	.914652	-1.181	.2466
FB	-.077016	-.093157	.788281	1.269	.788281	-.521	.6061
MEDAGE	-.116498	-.138859	.765469	1.306	.765469	-.781	.4409
PEDAGE	-.114129	-.136240	.767777	1.302	.767777	-.766	.4497
PL	.111660	.147602	.941468	1.062	.927656	.831	.4124
SX	-.107168	-.143040	.959837	1.042	.928696	-.805	.4271
@PA1LG	-.171279	-.172644	.547409	1.827	.531822	-.976	.3367
@PA2LG	.186510	.230530	.823132	1.215	.823132	1.319	.1968
@PA3LG	.006707	.008117	.789085	1.267	.789085	.045	.9642

Appendix 12

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	@PMLG	SCH	ST
1	2.72691	1.000	.00312	.00333	.04267	.01604
2	.92178	1.720	.00090	.00082	.00013	.93207
3	.33815	2.840	.00793	.01273	.89417	.03625
4	.01316	14.394	.98806	.98312	.06303	.01565

End Block Number 1 PIN = .050 Limits reached.

Residuals Statistics:

	Min	Max	Mean	Std Dev	N
*PRED	2.3459	3.0016	2.8544	.1318	41
*RESID	-.4863	.1608	-.0150	.1615	41
*ZPRED	-3.6477	1.1671	.0863	.9678	41
*ZRESID	-3.1592	1.0444	-.0971	1.0489	41

Total Cases = 41

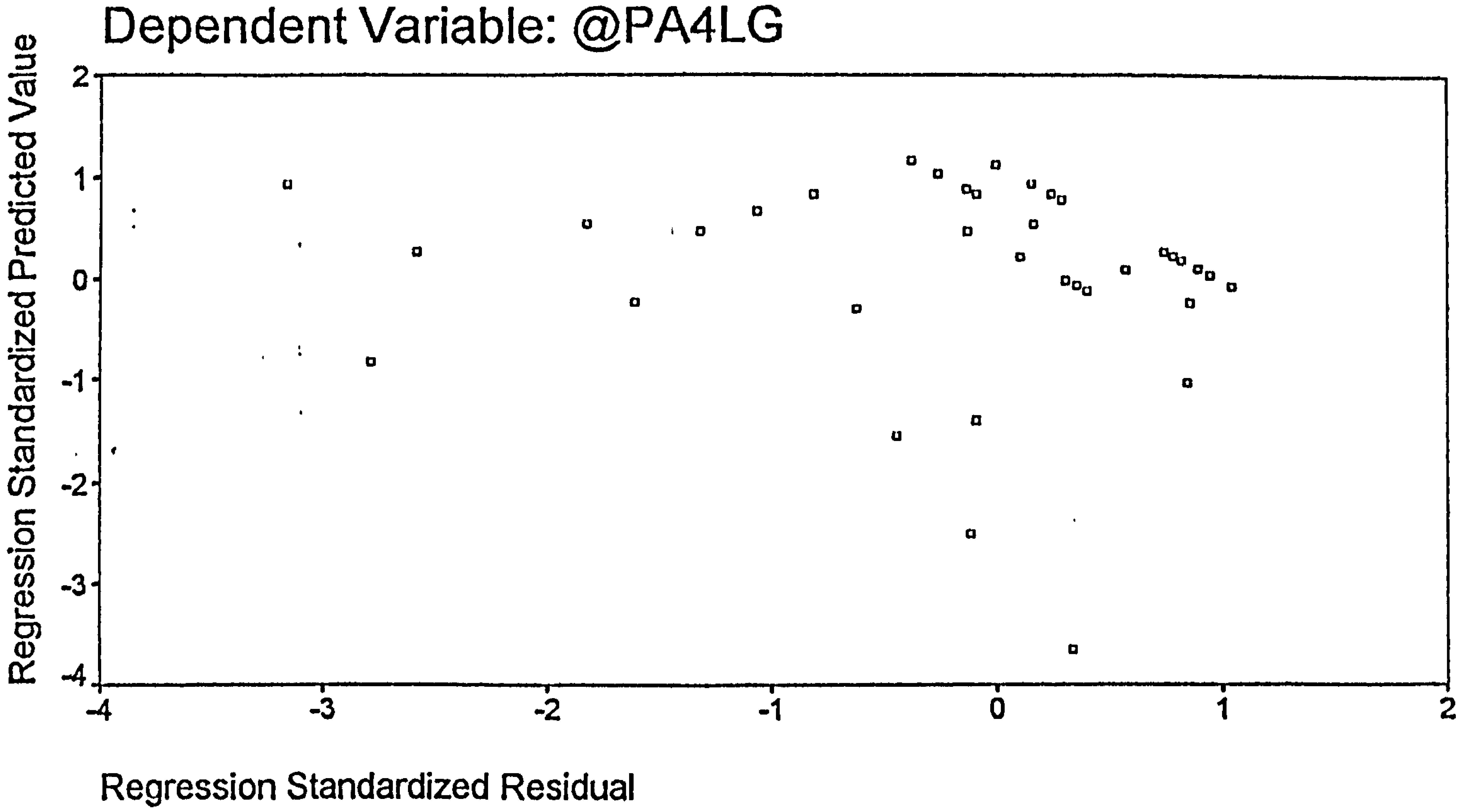
Hi-Res Chart # 18:Normal p-p plot of *zresid

Hi-Res Chart # 17:Scatterplot of *zpred with *zresid

Appendix 12

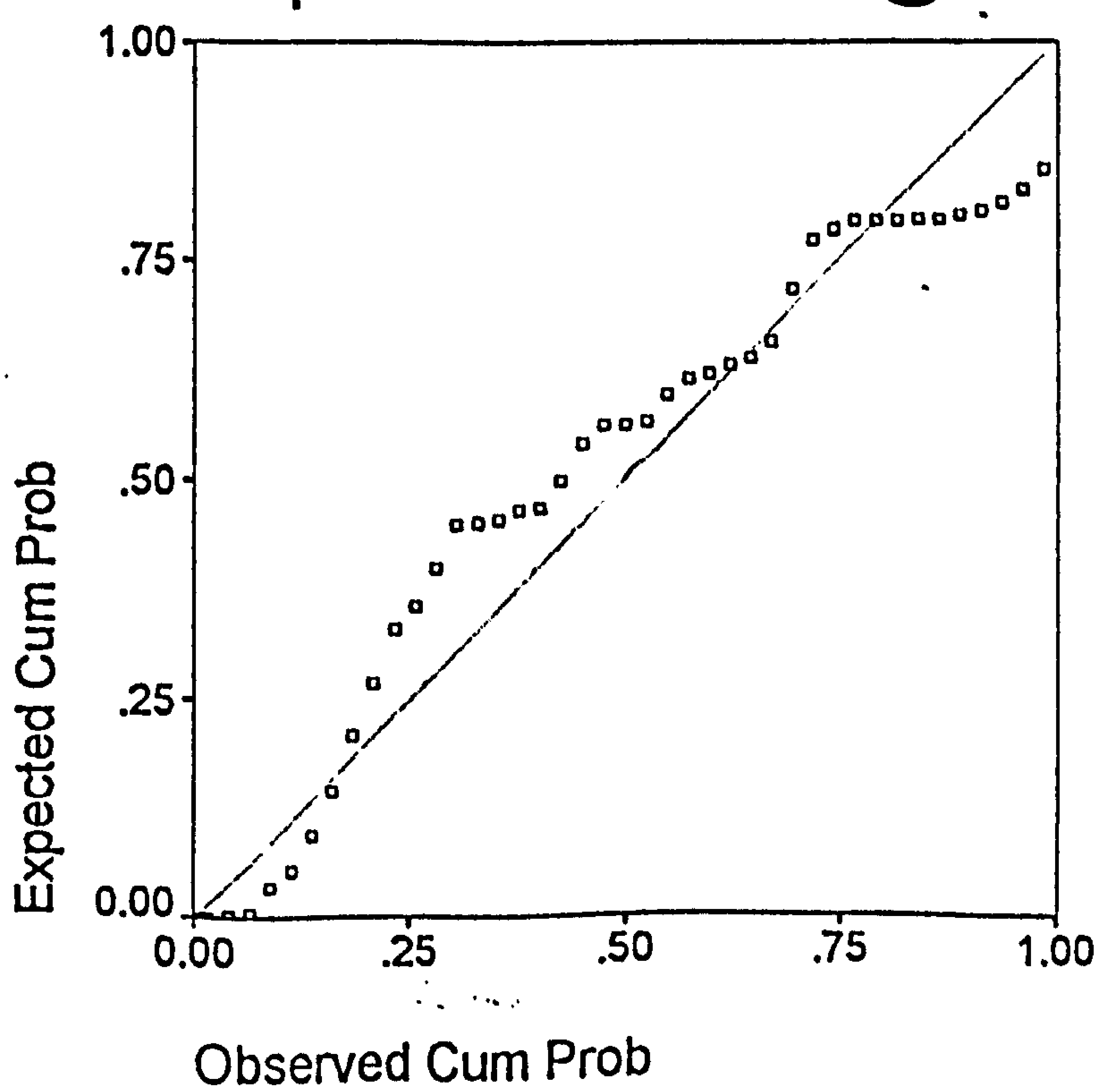
Scatterplot

Dependent Variable: @PA4LG



Normal P-P Plot of Regression Standardized

Dependent Variable: @PA4LG



APPENDIX 13

CHANGE OVER TIME

Appendix 13
Differences between means for test scores from 4 and five year old children[1]

--- t-tests for paired samples ---

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
@ADLG				2.8789	.114	.018
	41	.434	.005			
ADLOG				2.7888	.165	.026

Paired Differences Mean	SD	SE of Mean	t-value	df	2-tail Sig
.0901	.155	.024	3.73	40	.001
95% CI (.041, .139)					

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
@AMLG				2.9563	.299	.047
	41	.752	.000			
AMLOG				2.5925	.327	.051

Paired Differences Mean	SD	SE of Mean	t-value	df	2-tail Sig
.3638	.222	.035	10.50	40	.000
95% CI (.294, .434)					

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
@EATLG				4.0571	.148	.023
	41	.657	.000			
EATLOG				3.9864	.180	.028

Paired Differences Mean	SD	SE of Mean	t-value	df	2-tail Sig
.0707	.139	.022	3.26	40	.002
95% CI (.027, .114)					

[1] Variables names will be followed by the suffix lg, or log, to indicate transformed data

Appendix 13

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
@PALG				4.4381	.128	.020
	41	.571	.000			
PALOG				4.2566	.115	.018

Paired Differences					
Mean	SD	SE of Mean	t-value	df	2-tail Sig
.1814	.113	.018	10.24	40	.000
95% CI (.146, .217)					

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
@BCKLG				2.9297	.355	.057
	39	.616	.000			
BLLOG				2.2452	.560	.090

Paired Differences					
Mean	SD	SE of Mean	t-value	df	2-tail Sig
.6845	.442	.071	9.68	38	.000
95% CI (.541, .828)					

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
@PA1LG				3.3641	.125	.020
	41	.458	.003			
PA1ALG				2.9194	.126	.020

Paired Differences					
Mean	SD	SE of Mean	t-value	df	2-tail Sig
.4447	.131	.020	21.79	40	.000
95% CI (.403, .486)					

Appendix 13

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
@PA2LG				3.0682	.272	.042
	41	.203	.204			
PA2LOG				2.7346	.129	.020

Paired Differences Mean	SD	SE of Mean	t-value	df	2-tail Sig
.3336	.276	.043	7.74	40	.000
95% CI (.246, .421)					

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
@PA3LG				2.7807	.220	.034
	41	.299	.058			
PA3LOG				2.4347	.231	.036

Paired Differences Mean	SD	SE of Mean	t-value	df	2-tail Sig
.3460	.267	.042	8.29	40	.000
95% CI (.262, .430)					

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
@PA4LG				2.8394	.199	.031
	41	.289	.067			
PA4LOG				2.7819	.222	.035

Paired Differences Mean	SD	SE of Mean	t-value	df	2-tail Sig
.0575	.252	.039	1.46	40	.152
95% CI (-.022, .137)					

Appendix 13

Pearsons Product Moment Correlation Coefficients - -

	@PALG	ADLOG	AMLOG	BPVSLOG	EATLOG	PA1LOG
@PALG	1.0000	.3914	.5397	.5809	.4559	.4905
	(41)	(41)	(41)	(41)	(41)	(41)
	P= .	P=.011	P=.000	P=.000	P=.003	P=.001

- - Correlation Coefficients - -

	PA2LOG	PA3LOG	PA4LOG	PALOG	WIPPLOG
@PALG	.2564	.2576	.3485	.5708	.4577
	(41)	(41)	(41)	(41)	(41)
	P=.106	P=.104	P=.026	P=.000	P=.003

--- spearman correlation coefficients ---

PED	.4869					
	Sig .001					
PL	-.0126	-.2673				
	Sig .938	Sig .091				
SX	.2684	.0983	-.0462			
	Sig .090	Sig .541	Sig .774			
FB	-.4438	-.7071	.0684	-.1426		
	Sig .004	Sig .000	Sig .671	Sig .374		
MED	.3249	.5446	-.1054	-.1460	-.6477	
	Sig .038	Sig .000	Sig .512	Sig .362	Sig .000	
AUD	-.1375	-.0378	-.0378	-.2125	.1050	.0756
	Sig .424	Sig .827	Sig .827	Sig .213	Sig .542	Sig .661
	@PALG	PED	PL	SX	FB	MED

(Coefficient / (Cases) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

Appendix 13

- - Pearsons Product Moment Correlation Coefficients - -

	@PALG	PALOG
@PALG	1.0000 P= .	.5708 P= .000
PALOG	.5708 P= .000	1.0000 P= .

(Coefficient / (Cases) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

Appendix 13

STEPWISE MULTIPLE REGRESSION: **Dep. variable: Phonological awareness at 5**
Indep. variables: test scores at four

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. @PALG

Block Number 1. Method: Stepwise Criteria PIN .0500 POUT .1000
ADLOG AMLOG BPVSLOG AUD EATLOG FB MED PED
PL SX WIPPLOG PALOG

Variable(s) Entered on Step Number
1.. PALOG

Multiple R	.62611
R Square	.39202
Adjusted R Square	.37413
Standard Error	.10510

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	.24214	.24214
Residual	34	.37554	.01105

F = 21.92255 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
PALOG	.709205	.151470	.626112	1.000000	1.000	4.682
(Constant)	1.405748	.645679			2.177	

------ in ------

Variable	Sig T
PALOG	.0000
(Constant)	.0365

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
ADLOG	.049432	.053715	.717901	1.393	.717901	.309	.7593
AMLOG	.338104	.395281	.831007	1.203	.831007	2.472	.0188
BPVSLOG	.360514	.408334	.779969	1.282	.779969	2.570	.0149
AUD	-.015265	-.019538	.996057	1.004	.996057	-.112	.9113
EATLOG	.216662	.248592	.800387	1.249	.800387	1.474	.1499
FB	-.297060	-.369508	.940698	1.063	.940698	-2.284	.0289
MED	.270108	.338284	.953630	1.049	.953630	2.065	.0468
PED	.426607	.545711	.994862	1.005	.994862	3.741	.0007
PL	-.083310	-.105865	.981760	1.019	.981760	-.612	.5450
SX	.167695	.213889	.989081	1.011	.989081	1.258	.2173
WIPPLOG	.263622	.321610	.904869	1.105	.904869	1.951	.0596

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	PALOG
1	1.99963	1.000	.00018	.00018
2	.00037	73.711	.99982	.99982

Appendix 13

Variable(s) Entered on Step Number
2.. PED

Multiple R	.75702
R Square	.57307
Adjusted R Square	.54720
Standard Error	.08939

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	2	.35397	.17699
Residual	33	.26370	.00799

F = 22.14842 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
PED	.113345	.030298	.426607	.994862	1.005	3.741
PALOG	.674568	.129169	.595533	.994862	1.005	5.222
(Constant)	1.487225	.549630			2.706	

------ in ------

Variable	Sig T
PED	.0007
PALOG	.0000
(Constant)	.0107

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
ADLOG	-.015191	-.019536	.706105	1.416	.706105	-.111	.9127
AMLOG	.186071	.239621	.708018	1.412	.708018	1.396	.1723
BPVSLOG	.270421	.357183	.744820	1.343	.744820	2.163	.0381
AUD	-.001005	-.001535	.994943	1.005	.991247	-.009	.9931
EATLOG	.105853	.140464	.751753	1.330	.751753	.803	.4282
FB	.009161	.009867	.495287	2.019	.495287	.056	.9558
MED	.048339	.060738	.674019	1.484	.674019	.344	.7329
PL	.035199	.051396	.910197	1.099	.910197	.291	.7728
SX	.107982	.162625	.968326	1.033	.968326	.932	.3581
WIPPLOG	.187660	.268538	.874226	1.144	.874226	1.577	.1246

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	PED	PALOG
1	2.69060	1.000	.00010	.04470	.00010
2	.30903	2.951	.00035	.95219	.00034
3	.00037	85.636	.99956	.00311	.99956

Appendix 13
Variable(s) Entered on Step Number
3.. BPVSLOG

Multiple R	.79218
R Square	.62754
Adjusted R Square	.59262
Standard Error	.08479

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	3	.38762	.12921
Residual	32	.23006	.00719

F = 17.97186 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
BPVSLOG	.120020	.055482	.270421	.744820	1.343	2.163
PED	.099840	.029408	.375777	.950029	1.053	3.395
PALOG	.535013	.138465	.472329	.778905	1.284	3.864
(Constant)	1.653478	.526967			3.138	

----- in ------

Variable	Sig T
BPVSLOG	.0381
PED	.0018
PALOG	.0005
(Constant)	.0036

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
ADLOG	-.148159	-.187376	.595729	1.679	.595729	-1.062	.2964
AMLOG	.098817	.127054	.615736	1.624	.615736	.713	.4811
AUD	-.037578	-.060698	.971783	1.029	.727482	-.339	.7372
EATLOG	.002204	.002888	.639577	1.564	.633678	.016	.9873
FB	.024333	.028031	.494257	2.023	.494257	.156	.8769
MED	.032876	.044160	.671999	1.488	.671999	.246	.8072
PL	.115656	.173067	.834007	1.199	.682473	.978	.3355
SX	.091211	.146679	.963201	1.038	.740878	.826	.4153
WIPPLOG	.090717	.122825	.682769	1.465	.581703	.689	.4959

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	BPVSLOG	PED	PALOG
1	3.65958	1.000	.00005	.00036	.02160	.00004
2	.33639	3.298	.00015	.00084	.94132	.00012
3	.00371	31.406	.04446	.87588	.03656	.01606
4	.00033	105.992	.95534	.12292	.00051	.98378

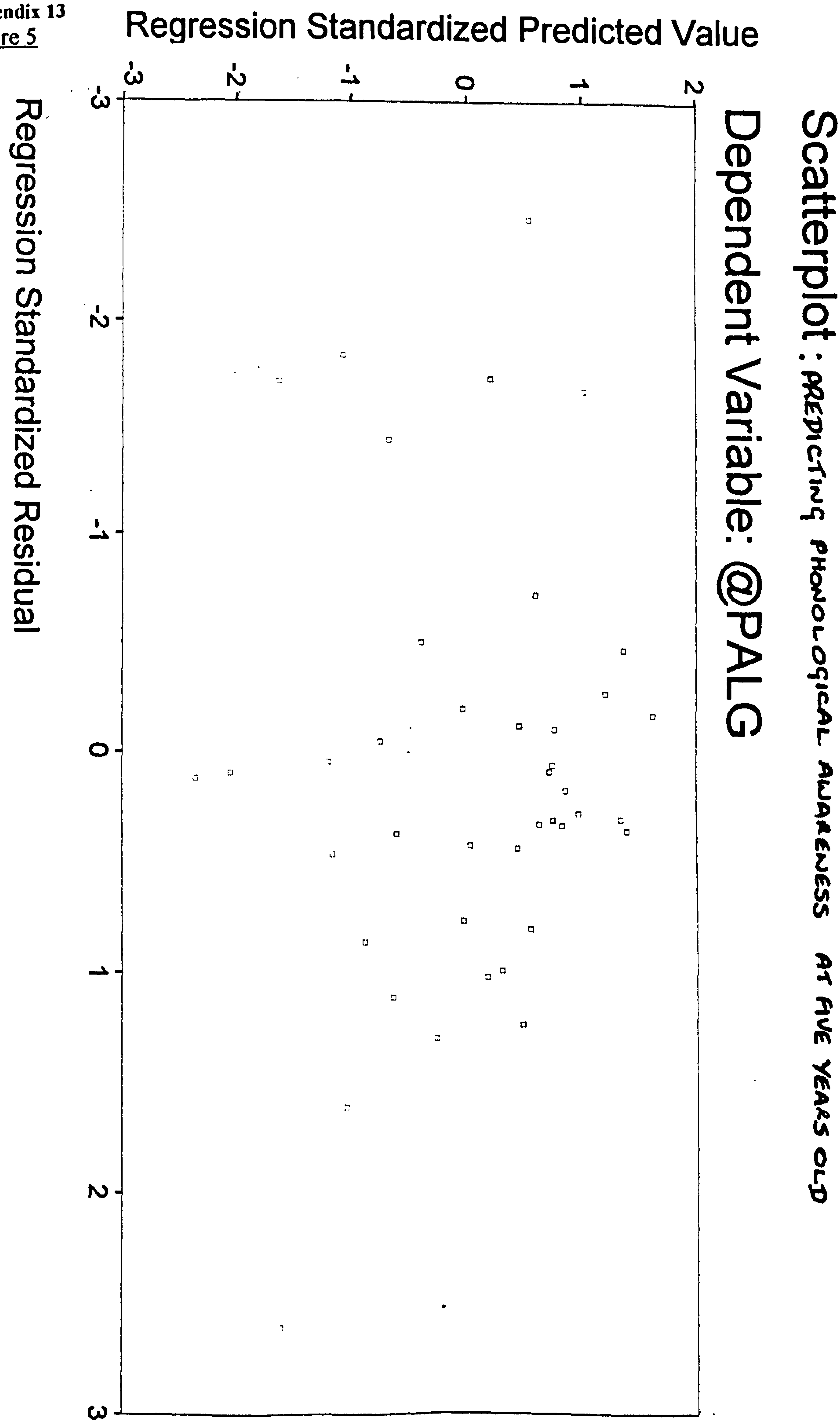
End Block Number 1 PIN = .050 Limits reached.

Residuals Statistics:

	Min	Max	Mean	Std Dev	N
*PRED	4.1793	4.5984	4.4315	.1059	41
*RESID	-.2087	.2211	.0066	.0851	41
*ZPRED	-2.3617	1.6212	.0352	1.0062	41
*ZRESID	-2.4609	2.6073	.0776	1.0041	41

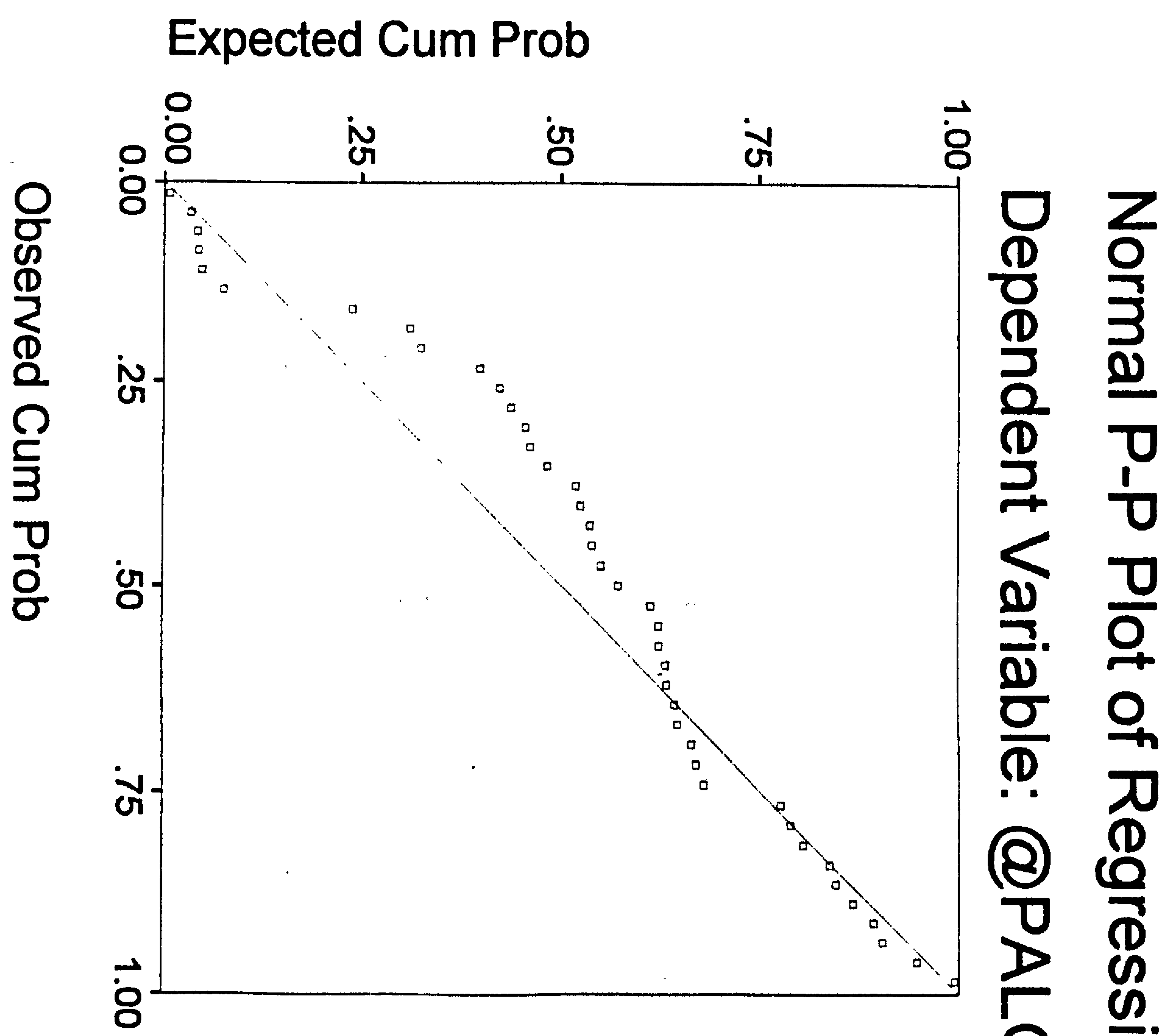
Total Cases = 41
Hi-Res Chart # 2:Normal p-p plot of *zresid
Hi-Res Chart # 1:Scatterplot of *zresid with *zpred

Appendix 13
<u>Figure 5</u>



Appendix 13
<u>Figure 6</u>

PREDICTING PHONOLOGICAL AWARENESS
AT FIVE YEARS OLD



Appendix 13

STEPWISE MULTIPLE REGRESSION **Dep variable: subtest pa1 at 5 years old**
Indep variable: Test scores at 4 years old

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. @PA1LG

Block Number 1. Method: Stepwise Criteria PIN .0500 POUT .1000
ADLOG AMLOG AUD BPVSLOG EATLOG FB MED PA2LOG
PA1LOG PA3LOG PA4LOG PED PL SX WIPPLOG

Variable(s) Entered on Step Number
1.. PA1LOG

Multiple R	.49546
R Square	.24548
Adjusted R Square	.22328
Standard Error	.11726

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	.15210	.15210
Residual	34	.46753	.01375

F = 11.06152 Signif F = .0021

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
PA1LOG	.316426	.095140	.495455	1.000000	1.000	3.326
(Constant)	2.323923	.311827				7.453

----- in -----

Variable	Sig T
PA1LOG	.0021
(Constant)	.0000

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
ADLOG	-.002941	-.003199	.892794	1.120	.892794	-.018	.9854
AMLOG	.010201	.011287	.923632	1.083	.923632	.065	.9487
AUD	.049039	.055262	.958151	1.044	.958151	.318	.7525
BPVSLOG	.198827	.225224	.968174	1.033	.968174	1.328	.1933
EATLOG	.170767	.195063	.984489	1.016	.984489	1.142	.2615
FB	-4.83704	-.000551	.979553	1.021	.979553	-.003	.9975
MED	.175462	.196969	.950839	1.052	.950839	1.154	.2567
PA2LOG	.052263	.060156	.999635	1.000	.999635	.346	.7314
PA3LOG	-.062715	-.072074	.996526	1.003	.996526	-.415	.6807
PA4LOG	-.026086	-.029005	.932794	1.072	.932794	-.167	.8686
PED	.262112	.301152	.996025	1.004	.996025	1.814	.0787
PL	-.243435	-.280251	.999998	1.000	.999998	-1.677	.1030
SX	.015459	.017797	.999959	1.000	.999959	.102	.9192
WIPPLOG	.071149	.080359	.962505	1.039	.962505	.463	.6463

Appendix 13
Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	PA1LOG
1	1.99803	1.000	.00098	.00098
2	.00197	31.879	.99902	.99902

End Block Number 1 PIN = .050 Limits reached.

Equation Number 1 Dependent Variable.. @PA1LG

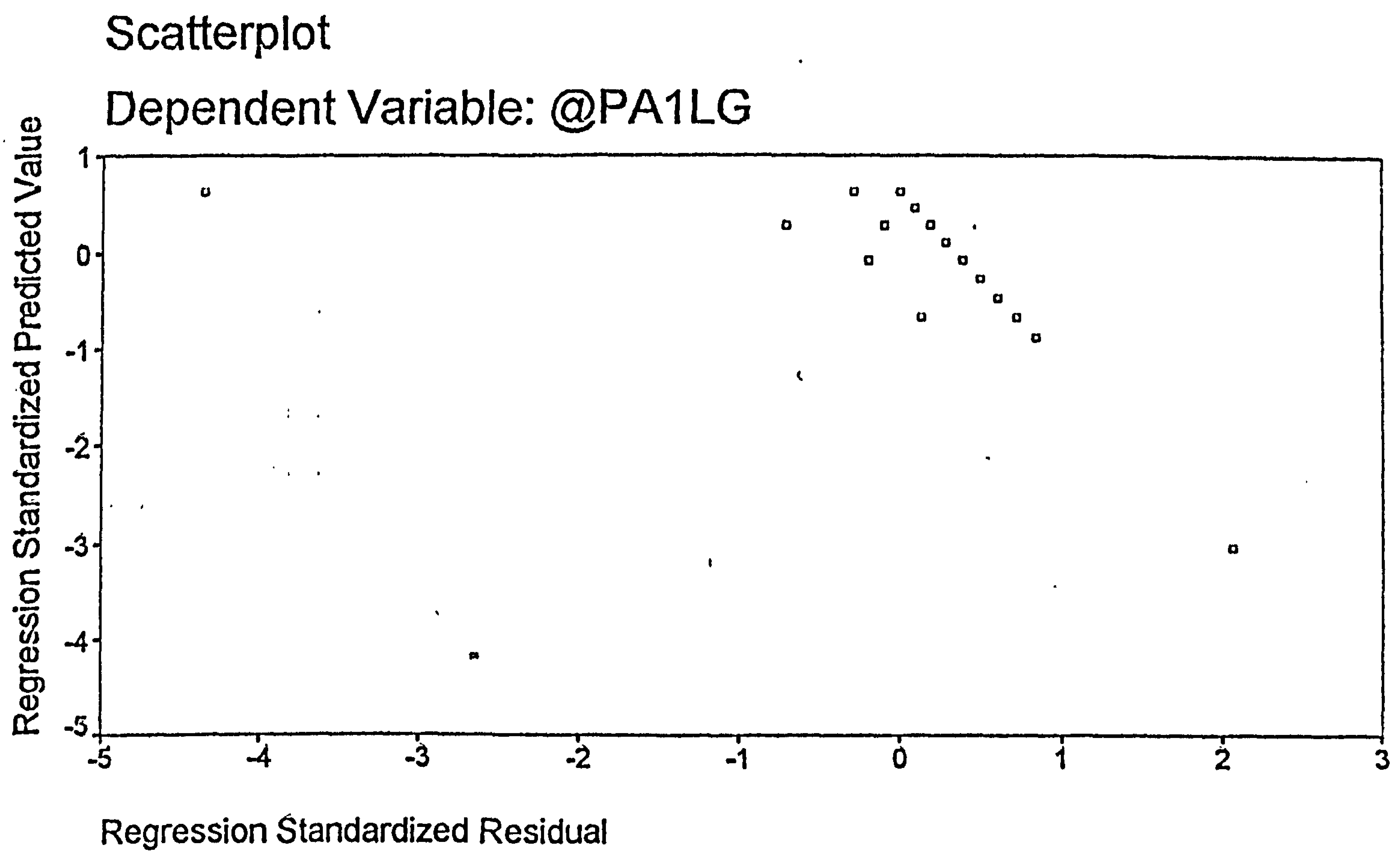
Residuals Statistics:

	Min	Max	Mean	Std Dev	N
*PRED	3.0827	3.4001	3.3620	.0630	41
*RESID	-.5098	.2422	.0021	.1087	41
*ZPRED	-4.1914	.6244	.0461	.9552	41
*ZRESID	-4.3473	2.0655	.0180	.9270	41

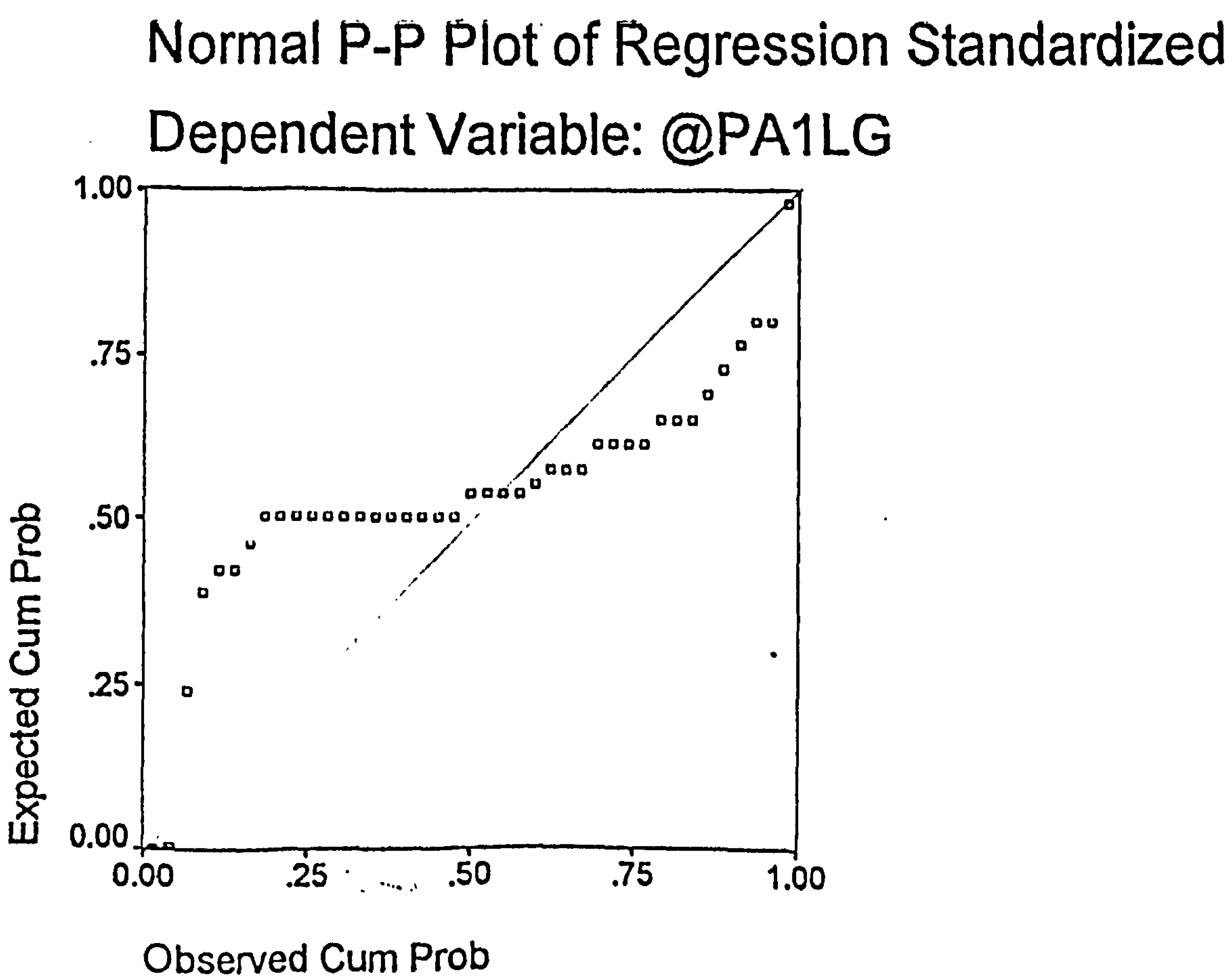
Total Cases = 41

Hi-Res Chart # 2:Normal p-p plot of *zresid
Hi-Res Chart # 1:Scatterplot of *zpred with *zresid

Appendix 13



Scatterplot
Dependent Variable: @PA1LG
Regression Standardized Predicted Value
1
0
-1
-2
-3
-4
-5
-5
-4
-3
-2
-1
0
1
2
3
Regression Standardized Residual



Normal P-P Plot of Regression Standardized
Dependent Variable: @PA1LG
Expected Cum Prob
1.00
.75
.50
.25
0.00
0.00
.25
.50
.75
1.00
Observed Cum Prob

Appendix 13

STEPWISE MULTIPLE REGRESSION **Dep variable: subtest pa2 at 5 years old**
Indep variable: Test scores at 4 years old

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. @PA2LG

Block Number 1. Method: Stepwise Criteria PIN .0500 POUT .1000
ADLOG AMLOG AUD BPVSLOG EATLOG FB MED PA2LOG
PA1LOG PA3LOG PA4LOG PED PL SX WIPPLOG

Variable(s) Entered on Step Number
1.. BPVSLOG

Multiple R	.43161
R Square	.18628
Adjusted R Square	.16235
Standard Error	.25586

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	.50954	.50954
Residual	34	2.22572	.06546

F = 7.78367 Signif F = .0086

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
BPVSLOG	.403107	.144487	.431607	1.000000	1.000	2.790
(Constant)	1.577917	.526965				2.994

----- in -----

Variable	Sig T
BPVSLOG	.0086
(Constant)	.0051

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
ADLOG	.015784	.014541	.690613	1.448	.690613	.084	.9339
AMLOG	.268992	.254574	.728819	1.372	.728819	1.512	.1400
AUD	-.016385	-.018081	.990855	1.009	.990855	-.104	.9179
EATLOG	.015025	.014019	.708432	1.412	.708432	.081	.9363
FB	-.200750	-.214464	.928686	1.077	.928686	-1.261	.2160
MED	.135354	.145704	.942911	1.061	.942911	.846	.4036
PA2LOG	.144316	.159403	.992740	1.007	.992740	.928	.3604
PA1LOG	.137133	.149583	.968174	1.033	.968174	.869	.3911
PA3LOG	.280366	.285047	.841114	1.189	.841114	1.708	.0970
PA4LOG	.238046	.235248	.794696	1.258	.794696	1.390	.1737
PED	.278567	.301202	.951326	1.051	.951326	1.815	.0787
PL	.278180	.300474	.949366	1.053	.949366	1.810	.0795
SX	.271019	.297577	.981009	1.019	.981009	1.791	.0825
WIPPLOG	.082124	.075724	.691839	1.445	.691839	.436	.6655

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	BPVSLOG
1	1.99672	1.000	.00164	.00164
2	.00328	24.675	.99836	.99836

Appendix 13

End Block Number 1 PIN = .050 Limits reached.
Residuals Statistics:

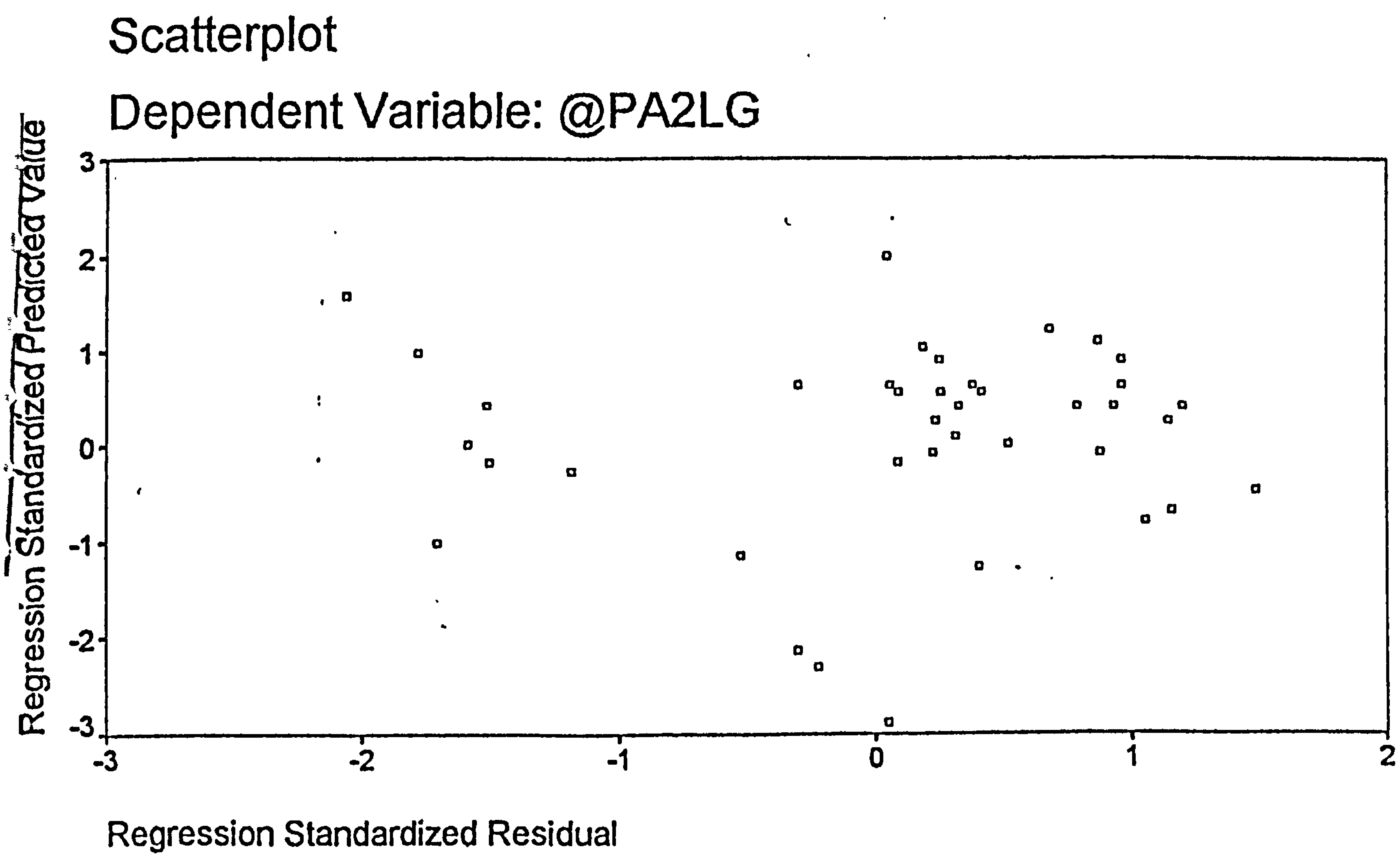
	Min	Max	Mean	Std Dev	N
*PRED	2.6956	3.2847	3.0550	.1209	41
*RESID	-.5270	.3799	.0131	.2411	41
*ZPRED	-2.8819	2.0010	.0972	1.0017	41
*ZRESID	-2.0597	1.4849	.0514	.9422	41

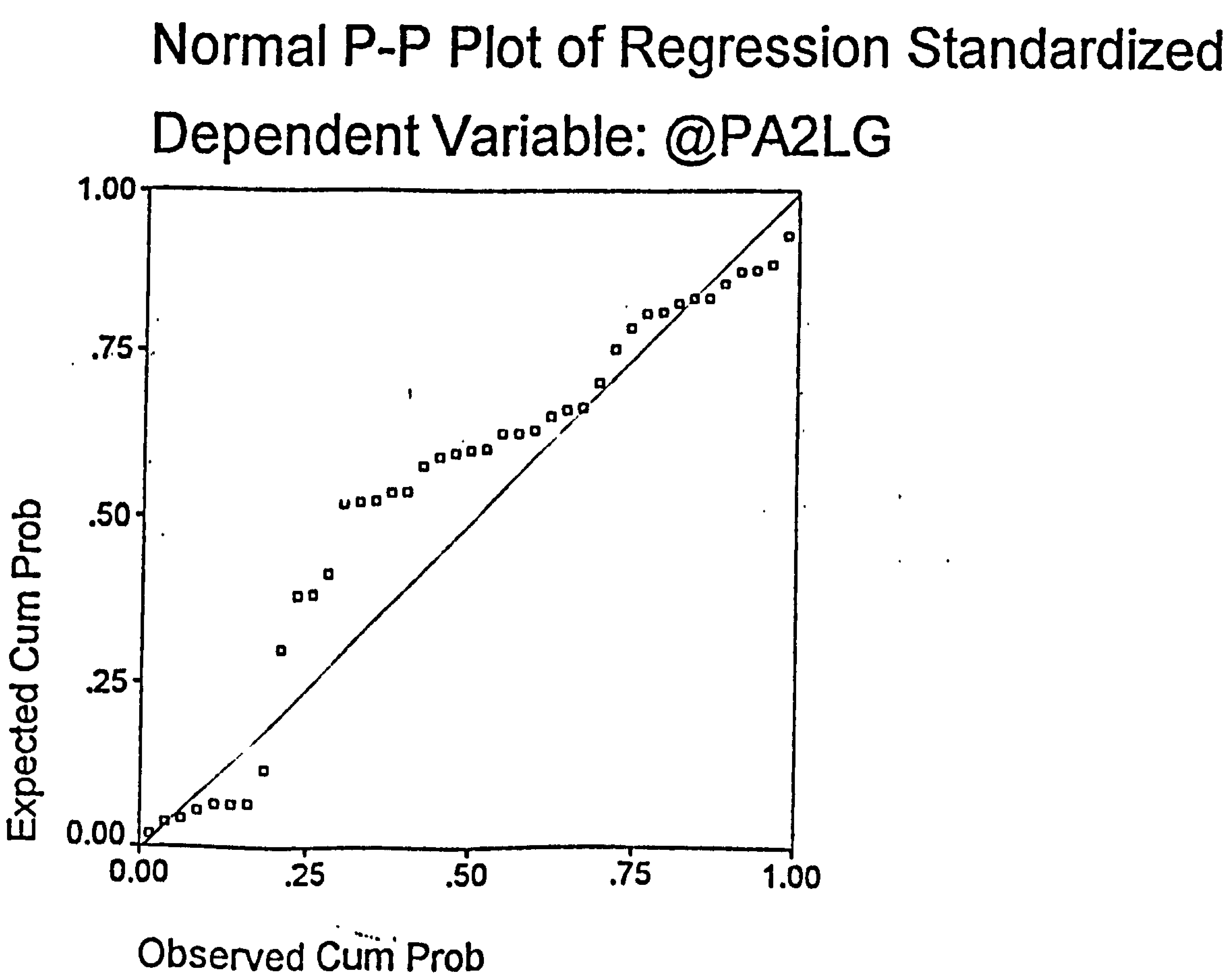
Total Cases = 41

Hi-Res Chart # 6:Normal p-p plot of *zresid

Hi-Res Chart # 5:Scatterplot of *zpred with *zresid

Appendix 13


Scatterplot
Dependent Variable: @PA2LG
Regression Standardized Predicted Value
3
2
1
0
-1
-2
-3
-3
-2
-1
0
1
2
Regression Standardized Residual


Normal P-P Plot of Regression Standardized
Dependent Variable: @PA2LG
Expected Cum Prob
1.00
.75
.50
.25
0.00
0.00
.25
.50
.75
1.00
Observed Cum Prob

Appendix 13
STEPWISE MULTIPLE REGRESSION

Dep variable: subtest pa3 at 5 years old
Indep variable: Test scores at 4 years old

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. @PA3LG

Block Number 1. Method: Stepwise Criteria PIN .0500 POUT .1000
ADLOG AMLOG AUD BPVSLOG EATLOG FB MED PA2LOG
PA1LOG PA3LOG PA4LOG PED PL SX WIPPLOG

Variable(s) Entered on Step Number
1.. BPVSLOG

Multiple R	.53327
R Square	.28438
Adjusted R Square	.26333
Standard Error	.19473

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	.51233	.51233
Residual	34	1.28924	.03792

F = 13.51127 Signif F = .0008

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
BPVSLOG	.404210	.109966	.533273	1.000000	1.000	3.676
(Constant)	1.293743	.401063				3.226

------ in ------

Variable	Sig T
BPVSLOG	.0008
(Constant)	.0028

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
ADLOG	.075855	.074517	.690613	1.448	.690613	.429	.6705
AMLOG	.197443	.199256	.728819	1.372	.728819	1.168	.2512
AUD	-.028378	-.033392	.990855	1.009	.990855	-.192	.8490
EATLOG	.344711	.342975	.708432	1.412	.708432	2.097	.0437
FB	-.400583	-.456337	.928686	1.077	.928686	-2.946	.0059
MED	.339962	.390234	.942911	1.061	.942911	2.435	.0205
PA2LOG	.218134	.256921	.992740	1.007	.992740	1.527	.1363
PA1LOG	.154930	.180206	.968174	1.033	.968174	1.052	.3002
PA3LOG	.225030	.243964	.841114	1.189	.841114	1.445	.1578
PA4LOG	.255944	.269715	.794696	1.258	.794696	1.609	.1171
PED	.267115	.307979	.951326	1.051	.951326	1.860	.0719
PL	.149194	.171841	.949366	1.053	.949366	1.002	.3236
SX	.258769	.302975	.981009	1.019	.981009	1.826	.0769
WIPPLOG	.108640	.106819	.691839	1.445	.691839	.617	.5414

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	BPVSLOG
1	1.99672	1.000	.00164	.00164
2	.00328	24.675	.99836	.99836

Appendix 13

Variable(s) Entered on Step Number
2.. FB

Multiple R	.65833
R Square	.43340
Adjusted R Square	.39906
Standard Error	.17588

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	2	.78080	.39040
Residual	33	1.02076	.03093

F = 12.62124 Signif F = .0001

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
BPVSLOG	.323126	.103063	.426299	.928686	1.077	3.135
FB	-.124170	.042147	-.400583	.928686	1.077	-2.946
(Constant)	1.805796	.401775				4.495

------ in ------

Variable	Sig T
BPVSLOG	.0036
FB	.0059
(Constant)	.0001

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
ADLOG	.021258	.023305	.680969	1.468	.672154	.132	.8959
AMLOG	.040897	.043313	.635528	1.573	.635528	.245	.8078
AUD	.013416	.017639	.979432	1.021	.915076	.100	.9211
EATLOG	.266100	.291953	.682040	1.466	.682040	1.727	.0939
MED	.165330	.173984	.627462	1.594	.617996	.999	.3251
PA2LOG	.227602	.301183	.992163	1.008	.921408	1.787	.0835
PA1LOG	.116657	.151720	.958383	1.043	.908616	.868	.3917
PA3LOG	.219646	.267595	.840974	1.189	.791996	1.571	.1260
PA4LOG	.213137	.251045	.786068	1.272	.763862	1.467	.1521
PED	.007643	.007404	.531763	1.881	.519107	.042	.9669
PL	.165280	.213774	.947851	1.055	.888720	1.238	.2248
SX	.186748	.240514	.939821	1.064	.889695	1.402	.1706
WIPPLOG	.019882	.021557	.666113	1.501	.666113	.122	.9037

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	BPVSLOG	FB
1	2.89009	1.000	.00063	.00071	.01499
2	.10705	5.196	.00627	.01122	.85267
3	.00286	31.806	.99310	.98806	.13234

End Block Number 1 PIN = .050 Limits reached.

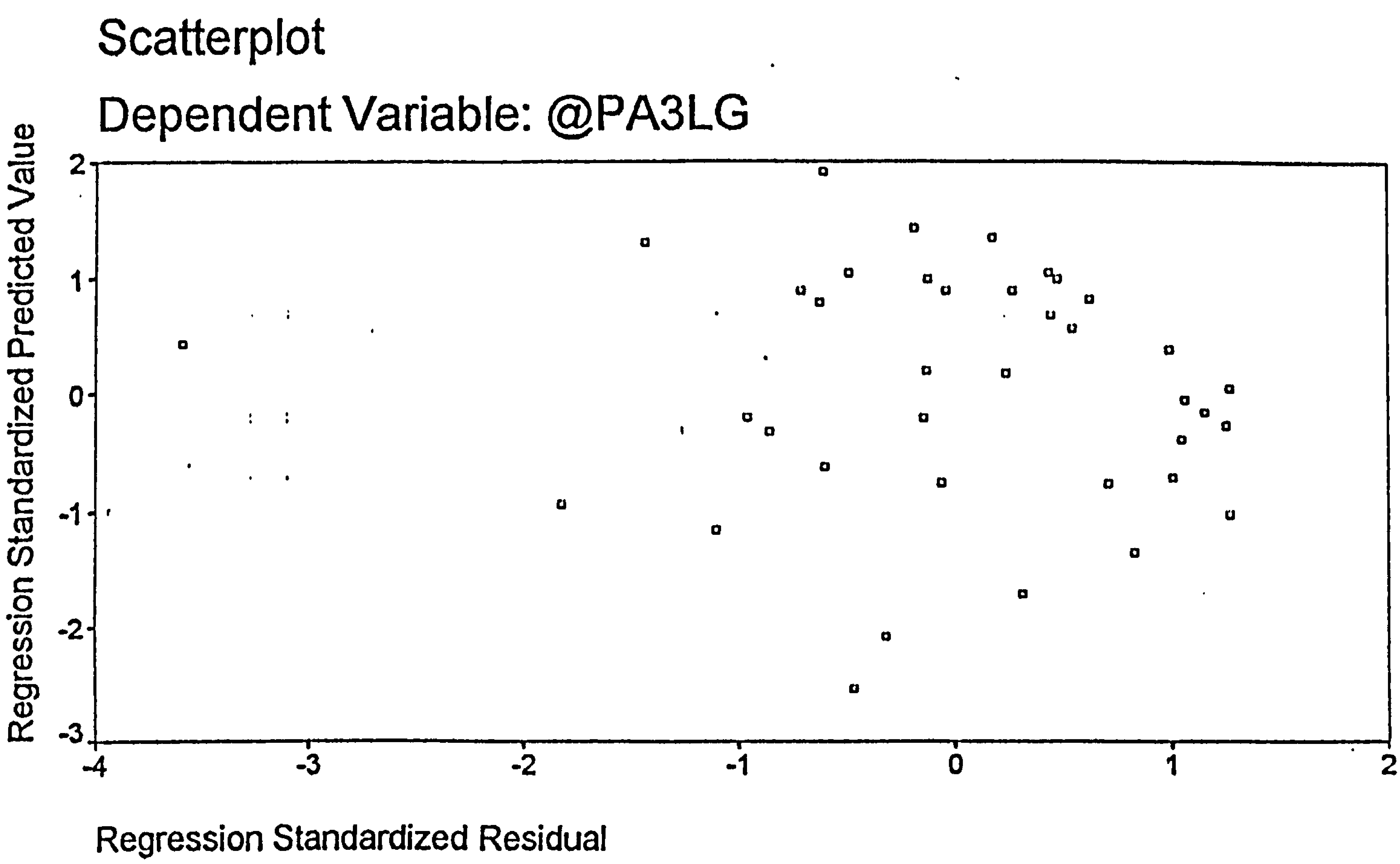
Appendix 13

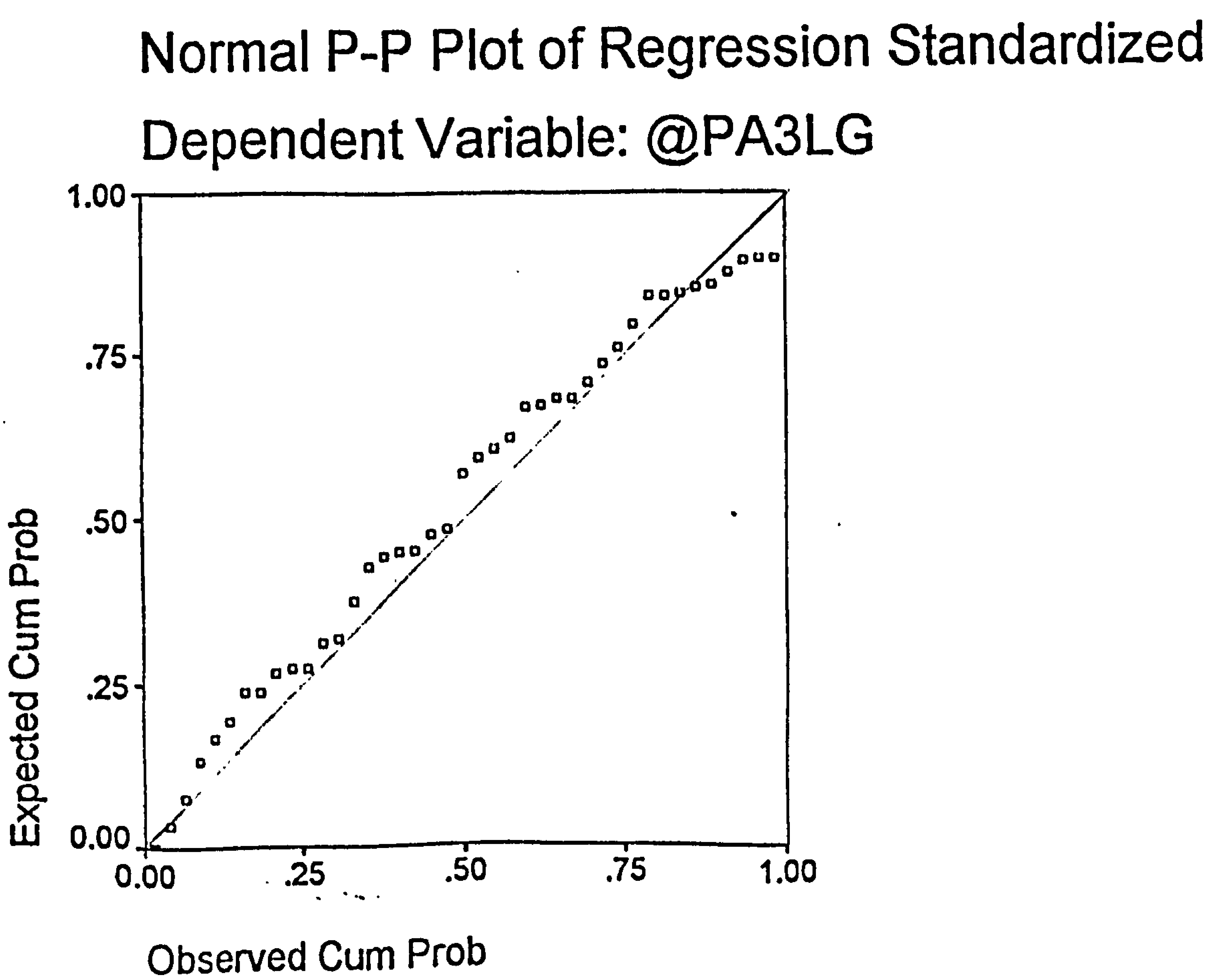
Residuals Statistics:

	Min	Max	Mean	Std Dev	N
*PRED	2.3847	3.0498	2.7778	.1512	41
*RESID	-.6307	.2230	.0029	.1716	41
*ZPRED	-2.5335	1.9192	.0984	1.0125	41
*ZRESID	-3.5861	1.2678	.0165	.9755	41

Total Cases = 41

Hi-Res Chart # 8:Normal p-p plot of *zresid
Hi-Res Chart # 7:Scatterplot of *zpred with *zresid


Scatterplot
Dependent Variable: @PA3LG
Regression Standardized Predicted Value
2
1
0
-1
-2
-3
-4
-3
-2
-1
0
1
2
Regression Standardized Residual


Normal P-P Plot of Regression Standardized
Dependent Variable: @PA3LG
Expected Cum Prob
1.00
.75
.50
.25
0.00
0.00
.25
.50
.75
1.00
Observed Cum Prob

Appendix 13

STEPWISE MULTIPLE REGRESSION **Dep variable: subtest pa4 at 5 years old**
Indep variable: Test scores at 4 years old

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. @PA4LG

Block Number 1. Method: Stepwise Criteria PIN .0500 POUT .1000
ADLOG AMLOG AUD BPVSLOG EATLOG FB MED PA2LOG
PA1LOG PA3LOG PA4LOG PED PL SX WIPPLOG

Variable(s) Entered on Step Number
1.. PA1LOG

Multiple R	.44853
R Square	.20118
Adjusted R Square	.17768
Standard Error	.18185

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	.28315	.28315
Residual	34	1.12431	.03307

F = 8.56259 Signif F = .0061

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
PA1LOG	.431725	.147538	.448527	1.000000	1.000	2.926
(Constant)	1.430421	.483565				2.958

----- in -----

Variable	Sig T
PA1LOG	.0061
(Constant)	.0056

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
ADLOG	.112260	.118679	.892794	1.120	.892794	.687	.4971
AMLOG	.343846	.369733	.923632	1.083	.923632	2.286	.0288
AUD	-.143689	-.157367	.958151	1.044	.958151	-.915	.3666
BPVSLOG	.194976	.214650	.968174	1.033	.968174	1.263	.2156
EATLOG	.240871	.267402	.984489	1.016	.984489	1.594	.1204
FB	-.296156	-.327951	.979553	1.021	.979553	-1.994	.0544
MED	.074286	.081046	.950839	1.052	.950839	.467	.6435
PA2LOG	.116253	.130047	.999635	1.000	.999635	.753	.4565
PA3LOG	.046422	.051849	.996526	1.003	.996526	.298	.7674
PA4LOG	.209383	.226260	.932794	1.072	.932794	1.334	.1912
PED	.202655	.226291	.996025	1.004	.996025	1.335	.1912
PL	-.048549	-.054320	.999998	1.000	.999998	-.313	.7566
SX	-.156058	-.174604	.999959	1.000	.999959	-1.019	.3158
WIPPLOG	.241051	.264597	.962505	1.039	.962505	1.576	.1245

Appendix 13
Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	PA1LOG
1	1.99803	1.000	.00098	.00098
2	.00197	31.879	.99902	.99902

Variable(s) Entered on Step Number
2.. AMLOG

Multiple R	.55712
R Square	.31038
Adjusted R Square	.26858
Standard Error	.17150

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	2	.43684	.21842
Residual	33	.97061	.02941

F = 7.42615 Signif F = .0022

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF	T
AMLOG	.211320	.092443	.343846	.923632	1.083	2.286
PA1LOG	.340264	.144783	.353506	.923632	1.083	2.350
(Constant)	1.187915	.468231				2.537

------ in ------

Variable	Sig T
AMLOG	.0288
PA1LOG	.0249
(Constant)	.0161

------------------ Variables not in the Equation ------------------

Variable	Beta In	Partial	Tolerance	VIF	Min Toler	T	Sig T
ADLOG	-.040301	-.041694	.738102	1.355	.738102	-.236	.8149
AUD	-.122820	-.144481	.954315	1.048	.893471	-.826	.4149
BPVSLOG	.036650	.037644	.727531	1.375	.694061	.213	.8326
EATLOG	.127326	.139229	.824584	1.213	.773612	.795	.4323
FB	-.190570	-.206734	.811573	1.232	.765242	-1.195	.2408
MED	-.017899	-.020247	.882434	1.133	.857185	-.115	.9095
PA2LOG	.126897	.152703	.998623	1.001	.922698	.874	.3886
PA3LOG	-.046995	-.054367	.922952	1.083	.855441	-.308	.7601
PA4LOG	.075109	.078709	.757312	1.320	.749875	.447	.6581
PED	.090642	.100884	.854272	1.171	.792183	.574	.5702
PL	.028589	.033513	.947605	1.055	.875240	.190	.8508
SX	-.262491	-.304703	.929255	1.076	.858325	-1.810	.0797
WIPPLOG	.045172	.041194	.573502	1.744	.550340	.233	.8171

Collinearity Diagnostics

Number	Eigenval	Cond Index	Variance Proportions Constant	AMLOG	PA1LOG
1	2.98845	1.000	.00042	.00159	.00041
2	.00959	17.656	.06816	.99721	.05954
3	.00196	39.006	.93142	.00119	.94006

End Block Number 1 PIN = .050 Limits reached.

Appendix 13

Residuals Statistics:

	Min	Max	Mean	Std Dev	N
*PRED	2.4904	3.0568	2.8521	.1106	41
*RESID	-.4589	.2493	-.0126	.1745	41
*ZPRED	-3.1528	1.9169	.0844	.9901	41
*ZRESID	-2.6761	1.4538	-.0736	1.0173	41

Total Cases = 41

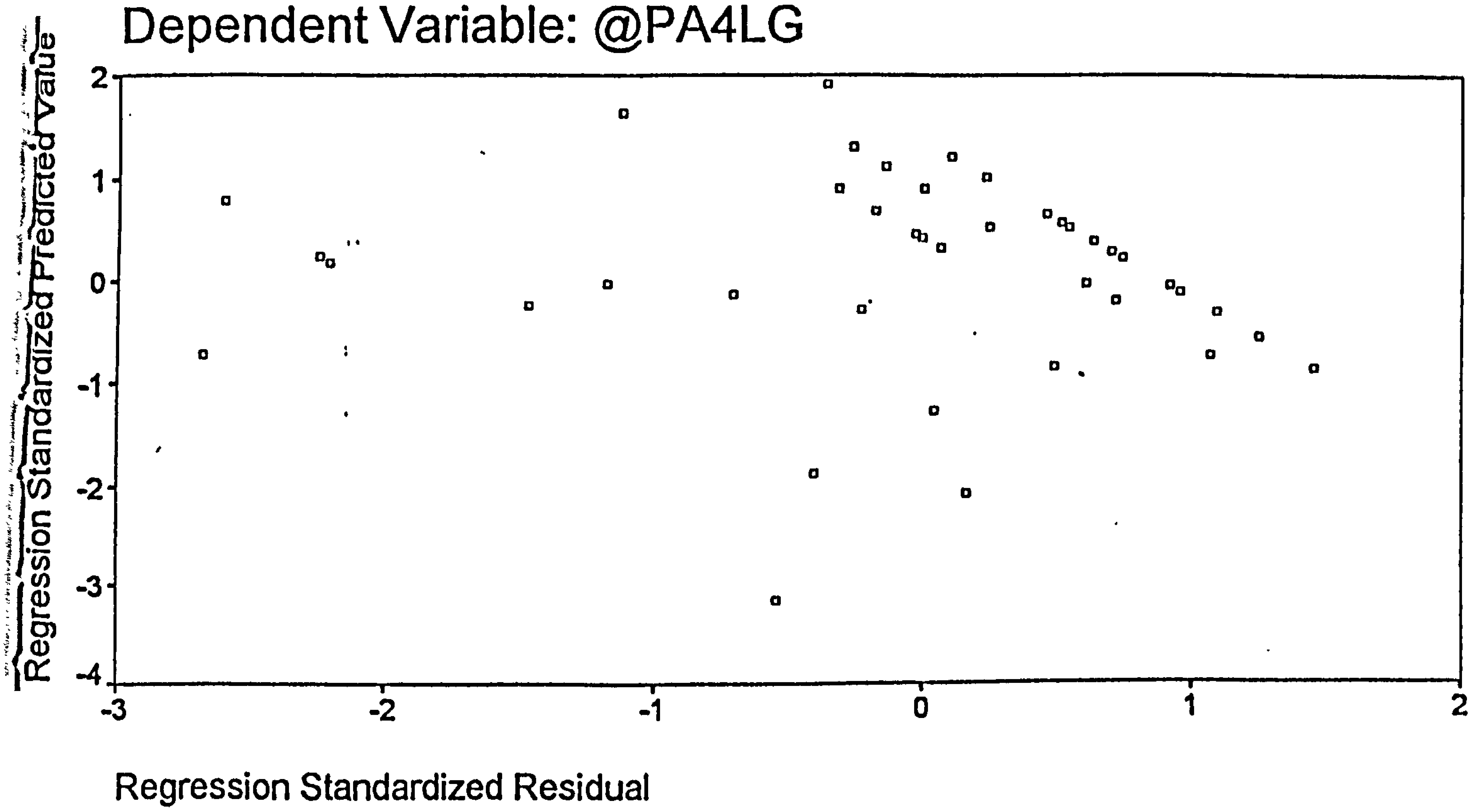
Hi-Res Chart # 10:Normal p-p plot of *zresid

Hi-Res Chart # 9:Scatterplot of *zpred with *zresid

Appendix 13

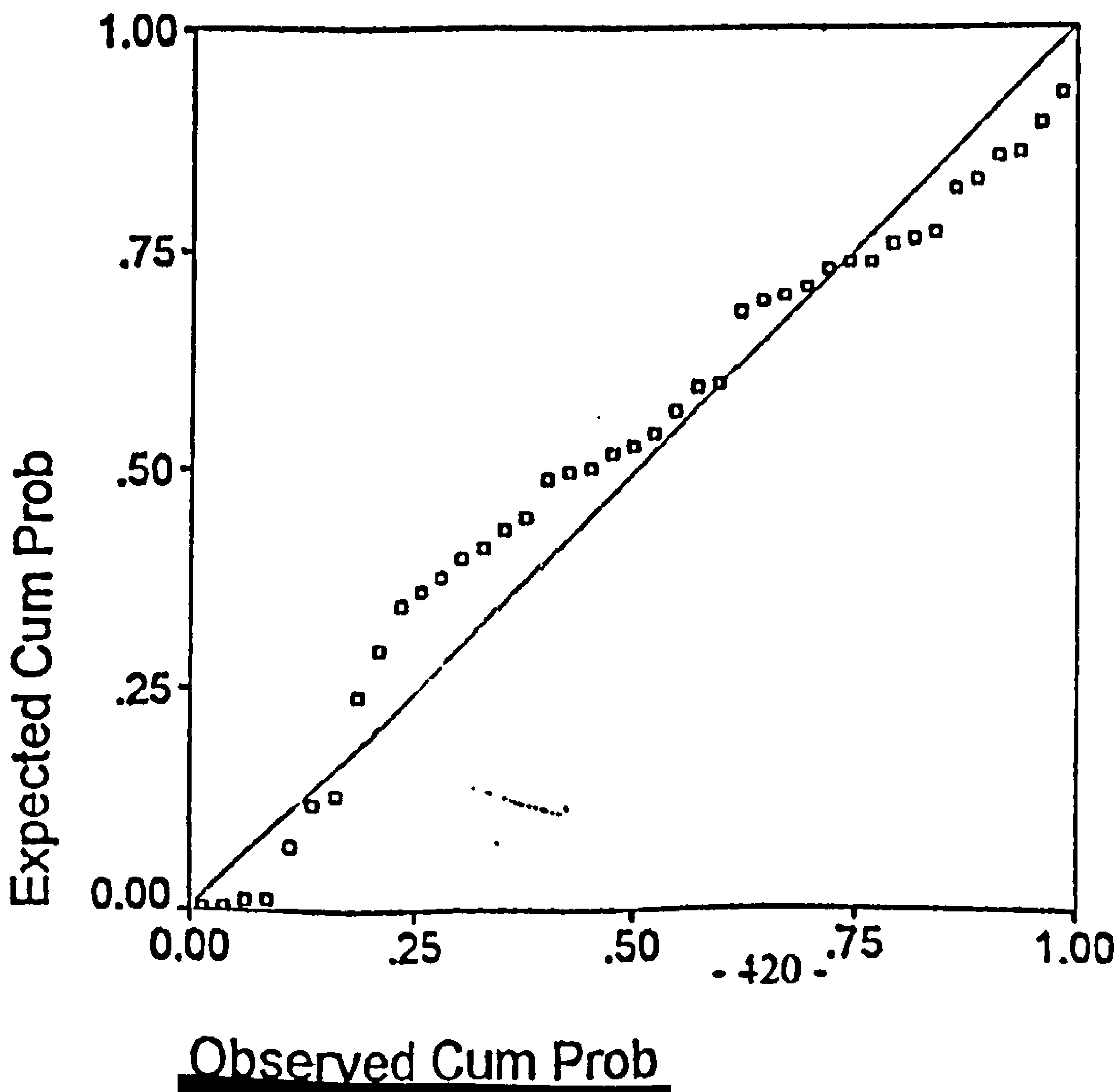
Scatterplot

Dependent Variable: @PA4LG



Normal P-P Plot of Regression Standardized

Dependent Variable: @PA4LG



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